determined from the nomograms described in sections 5.2.2 to 5.2.5. The multiple centers need not have equal areas nor equal numbers of isohyets. An example of multiple cell construction is shown in figure 22. In this figure, pattern X represents a single center, and pattern Y a double-centered pattern derived from pattern X. In pattern Y the enclosed area of the A isohyet equals that of A in pattern X. The sum of the areas of the two B centers in pattern Y equals that of B in pattern X, and similarly for the C isohyets. This approach satisfies the requirement to keep the volume of PMP constant, regardless of pattern selected. The magnitudes of the A, B and C isohyets in X and Y are the same.

Supplemental isohyets may be necessary to provide sufficient isohyets for coverage of small multiple centered patterns. Intermediate isohyets can be determined by the technique in section 3.4.

5.4.2 Arrangement of centers

Actual storms show a multitude of possible placements of the two centers. As the size of the drainage increases, the number of arrangements that are possible also increases. It is left to the user to determine the most critical hydrologic arrangement for a specific drainage situation. This arrangement should not violate the basic elliptical shape of the total isohyetal pattern.

6. SHORT-DURATION PRECIPITATION

6.1 Introduction

In applying PMP estimates to determine flood hydrographs, it is often necessary to determine the amounts that fell within time increments of less than 6 hr. Severe storms have occurred in which all, or nearly all, of the rain fell in periods of less than an hour. In other situations, the rainfall has been much more uniform, with large amounts falling every hour for several days. It is the purpose of this chapter to develop criteria for the maximum 5-, 15-, 30- and 60-min amounts that occur within the largest 6-hr increment of PMP determined from HMR No. 51. Another important feature is the temporal distribution of these short-duration values within the greatest 6-hr increment. This has not been studied for the present report. It is left to the discretion of the analyst to place these values chronologically in the most critical sequence.

6.2 Data

The amount of storm-centered data available for durations between 1 and 6 hr is limited. Of the total storm sample available in the United States east of the 105th meridian only 29, or about 6 percent, had data for the 1-hr duration. These storms are listed in table 19 and provide a basis for much of the analysis in this chapter. For many storms, data are insufficient to define an accurate isohyetal pattern near the storm center. In these cases the value for the largest observation, or the innermost isohyet drawn, is assumed to represent the average depth over a 10-mi^2 area. Of our storm sample, 12 had sufficient data to define the areal distribution to the nearest square mile. These storms are identified by an asterisk in table 19.

Many of the storms in table 19 did not last more than a few hours. Since the information in HMR No. 51 is restricted to areas of 10 mi^2, or larger, it was necessary to define a relationship between point and 10-mi^2 values for 6 and 12

Table 19.—Storms used in analysis of 1-hr storm-area averaged PMP values

Location of storm center Nearest station	Lat. (°)	Lat. (')	Long. (°)	Long. (')	Date	Storm assignment number+
Baltimore, MD	39	17	79	37	7/12/1903	SA 1-6
Bonaparte (nr), IA	40	42	91	48	6/9-10/1905	UMV 2-5
Cambridge, OH	40	02	81	36	7/16/1914	OR 2-16
Gordon, PA	40	45	76	20	8/21-22/1915	SA 1-7
Oakdale, NE	42	04	97	58	7/16-17/1920	MR 4-18
Lancaster, PA	40	03	76	17	8/18/1920	SA 1-8
Baltimore, MD	39	17	76	37	10/9-10/1922	SA 1-9
Harrisburg, PA	40	13	76	51	8/8/1925	SA 1-10
Toledo, IA	42	00	92	34	8/1-2/1929	UMV 2-17
Lakeville, PA	42	27	75	16	7/24/1933	SA 1-11
Woodward Ranch, TX	29	20	99	18	5/31/1935	GM 5-20
Elm Grove, WV*	40	03	80	40	7/10/1937	OR 9-15
Pickwick, TN	35	05	88	14	8/21-25/1937	OR 3-25
Winchester Spr., TN*	35	12	86	12	7/8/1938	—
Lucas Garrison, MO*	38	45	90	23	8/25/1939	UMV 3-19
Washington, D.C.	38	54	77	03	7/23/1940	—
Ewan, NJ*	39	42	75	12	9/1/1940	NA 2-4
Plainville, IL*	39	48	91	11	5/22/1941	UMV 2-19
Iowa City, IA*	41	38	91	33	9/8/1942	UMV 2-21
Gering (nr), NE*	41	49	103	41	6/17-18/1947	MR 7-16
Holt, MO	39	27	94	20	6/22-23/1947	MR 8-20C
St. Louis, MO*	38	36	90	18	7/5/1948	UMV 3-27
Marsland (nr), NE*	42	36	103	06	7/27-28/1951	MR 10-7
Kelso, MO	37	12	89	33	8/11-12/1952	UMV 3-30
Ritter, IA	43	15	95	48	6/7/1953	MR 10-8
Tulsa, OK*	36	11	95	54	7/25/1963	--
--*	35	22	98	18	9/20-21/1965	--
Glen Ullin, ND*	47	21	101	19	6/24/1966	--
Greeley (nr), NE	41	33	98	32	8/12-13/1966	--

+These numbers are assigned by the Corps of Engineers (indexed to major drainages) and are given in "Storm Rainfall" (U. S. Army Corps of Engineers 1945-). Storms without index numbers are from less complete storm studies maintained in the Hydrometeorological Branch.

*Storms for which an isohyetal pattern was developed that permitted determination of areal values for 1 mi^2 and larger.

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hr. For this purpose another storm sample was selected that consisted of all storms in "Storm Rainfall" (U. S. Army Corps of Engineers 1945-) for which adequate data were available to define depth-area relations between 1 and 10 mi^2. These 54 storms are listed in table 20.

Table 20.—Storms used to define 1- to 10-mi^2 area ratios for 6 and 12 hr

Location of storm center Nearest station	Lat. (°)	Lat. (')	Long. (°)	Long. (')	Date	Storm assignment number+
Constableville, NY	43	44	74	46	7/1-5/1890	GL 1-2
S. Canisteo, NY	42	15	77	33	9/8-13/1890	GL 4-1
Blanchard, IA	40	31	95	13	7/6-7/1898	MR 1-3A
Girardville, PA	40	48	76	17	8/3-5/1898	SA 1-4
Friesburg, NJ	39	35	75	25	9/12-15/1904	NA 1-9
Bonaparte (nr), IA	40	42	91	48	6/9-10/1905	UMV 2-5
Arkadelphia, AR	34	07	93	03	6/28-7/2/1905	MR 1-16B
Elk, NM	32	56	105	17	7/21-25/1905	GM 3-13
LaFayette, LA	30	14	91	59	5/7-10/1907	LMV 3-12
Sugarland, TX	29	36	95	38	5/28-31/1907	LMV 3-13
Ardmore, OK	34	12	97	08	7/12-15/1927	SW 2-5
Cheltenham, MD	38	44	76	51	8/10-13/1928	NA 1-18
Algiers, LA	29	56	90	03	9/5-9/1929	LMV 4-13
Meeker, OK	35	30	96	54	6/2-6/1932	SW 2-7
Tribune, KS	38	28	101	46	6/2-6/1932	SW 2-7A
St. Fish Htchry., TX*	30	10	99	21	6/30-7/2/1932	GM 5-1
Elka Park, NY	42	10	74	14	10/4-6/1932	NA 1-21
Peekamoose, NY	41	56	74	23	8/20-24/1933	NA 1-24A
York, PA	39	55	76	45	8/20-24/1933	NA 1-24B
Cheyenne (nr), OK*	35	37	99	40	4/3-4/1934	SW 2-11
Cherry Ck., CO*#	39	13	104	32	5/30-31/1935	MR 3-28A
Keene, OH	40	16	81	52	8/6-7/1935	OR 9-11
Bentonville, AR	36	22	94	13	9/6-10/1937	SA 2-15A
Cherokee, OK	36	45	98	22	9/6-10/1937	SW 2-15B
New Orleans, LA	29	57	90	04	9/30-10/4/1937	LMV 4-22A
Woodworth, LA	31	08	92	29	9/30-10/4/1937	LMV 4-22B
Loveland (nr), CO	40	23	105	04	8/30-9/4/1938	MV 5-8
Miller Island, LA*	29	45	92	10	8/6-9/1940	LMV 4-24
Ewan, NJ	39	42	75	12	9/1/40	NA 2-4
Hallett, OK*	36	15	96	36	9/2-6/1940	SW 2-18
Larchmont, NY	40	55	73	46	7/26-28/1942	NA 2-7
Charlottesville, VA	38	02	78	30	8/7-10/1942	NA 2-8
Warner, OK	35	29	95	18	5/6-12/1943	SW 2-20
Mounds (nr), OK*	35	52	96	04	5/12-20/1943	SW 2-21
Pierce (nr), NE	42	12	97	32	5/10-12/1944	MR 6-13
Stanton (nr), NE*	41	52	97	03	6/10-13/1944	MR 6-15
Turkey Ridge St., SD	43	16	97	08	6/10-13/1944	MR 6-15A
New Brunswick, NJ	40	29	74	27	9/12-15/1944	NA 2-16
Cedar Grove, NJ	40	52	74	13	7/22-23/1945	NA 2-17
Jerome, IA	40	43	93	02	7/16-17/1946	MR 7-9

Table 20.--Storms used to define 1- to 10-mi^2 area ratios for 6 and 12 hr - Continued

Nearest station	Lat. (°)	Lat. (')	Long. (°)	Long. (')	Date	Storm assignment number+
Collinsville, IL	38	40	89	59	8/12-16/1946	MR 7-2B
Holt (nr), MO	39	27	94	20	6/18-23/1947	MR 8-20
Wickes, AR*	34	14	94	20	8/27-28/1947	SW 3-7A
Dallas, TX	32	51	96	51	8/24-27/1947	SW 3-7B
Mifflin, WI	42	52	90	21	7/15-16/1950	UMV 3-28
Dumont (nr), IA	42	44	92	59	6/25-26/1951	UMV 3-29
Council Gr. (nr), KS	38	40	96	30	7/9-13 /1951	MR 10-2
Vic Pierce, TX*	30	22	101	23	6/23-28/1954	SW 3-22
New Bern, NC	35	07	77	03	8/10-15/1955	NA 2-21B
Slide Mtn., NY	42	01	74	25	8/11-15/1955	NA 2-21A
Big Meadows, VA	38	31	78	26	8/15-19/1955	NA 2-22B
Westfield, MA	42	07	72	45	8/17-20/1955	NA 2-22A
Big Elk Mdw. Res., CO	40	16	105	25	5/4-8/1969	--
Broomfield (nr), CO	39	55	105	06	5/5-6/1973	--

+ - See note for table 19.
# - Westernmost center of two large nearly equal amounts, generally known as Cherry Ck. The easternmost center is at Hale CO, 39° 36'N, 102° 08'W (see table 1).
* - Storms with larger 6- and 12-hr values used in depth-area development.

Data for durations less than 1 hr are not available from the storm studies prepared for "Storm Rainfall" (U. S. Army Corps of Engineers 1945-). For these durations maximum annual values were used. These values were determined from excessive precipitation tables of "Climatological Data" (National Weather Service 1914-).

6.3 1-hr PMP

Since maximum 1-hr data are relatively scarce, it has been necessary to resort to indirect methods to develop the 1-hr PMP. The primary tool was the development of depth-duration ratios for point or 1-mi^2 precipitation. These were used to develop 1-mi^2 1-hr PMP maps. Depth-area ratios developed from storm values were used to develop maps for other area sizes.

6.3.1 Depth-duration ratios

The first step in this procedure is to develop depth-duration ratios for durations from 5 min to 12 hr along meridians at 2° intervals starting at 69°W. Depth-duration curves were prepared for each 2° of latitude from 29°N. For 6- and 12-hr durations, the 10-mi^2 values from HMR No. 51 were used. Values for the 2- and 3-hr durations were obtained for the 100-yr recurrence interval from Weather Bureau Technical Paper No. 40 (Hershfield 1961). For the shorter durations, 5, 10, 15, 30 and 60 min, the 100-yr amounts were determined from NOAA Technical Memorandum NWS 35 (Frederick et al. 1977). Along the 105th meridian, however, all rainfall-frequency values were determined from NOAA Atlas 2 (Miller et al. 1973).

All values were expressed as a percent of the 6-hr 10-mi^2 amount, and a smooth set of curves was developed for each meridian. These curves (not shown) indicate that the ratio between amounts for durations less than 6 hr and the 6-hr amount decreased from north to south. This variation was consistent along all meridians. The same trend can be seen by examining 6- to 24-hr ratios in PMP values of HMR No. 51. Although considerable scatter is present when 1- to 6-, 2- to 6-, or 3- to 6-hr ratios in major storms are examined, a trend toward increasing ratios with latitude can also be detected. After constructing a smooth family of curves along the meridian, the 1-hr pt. to 6-hr 10-mi^2 ratios were plotted and regionally smoothed (fig. 23). This smoothing step required changes of less than 2 percent from the values determined from the sets of curves.

6.3.2 1-hr 1-mi^2 PMP

The ratio map of figure 23 was used to compute 1-hr 1-mi^2 PMP values over a 2° grid from the 6-hr 10-mi^2 PMP amounts shown in HMR No. 51. These values were plotted and isohyets drawn as shown in figure 24. The 1-hr data used to develop the 1- to 6-hr ratios were based upon single station observations, and the resulting maps can be considered "point" values. We have developed a convention for this report that they should be considered applicable to 1 mi^2. We do not recommend any increase in these values for smaller areas.

Though the paucity of data prevents development of the 1-hr 1-mi^2 PMP by traditional methods, an important step in evaluating the reasonableness of the PMP values developed is to compare the limited data available with the derived map. Table 21 shows the important 1-hr values used in this comparison. In most cases, 1-hr values are not obtainable directly from the observations of the most extreme rainfall in the storm and must be estimated by indirect methods. The technique used for each storm is indicated in the remarks column.

These maximum observed amounts together with the moisture maximized values are shown in figure 25. There are only a few storms that provide controlling or near controlling values: a) Smethport, Pennsylvania; b) Glen Ullin, North Dakota; c) Buffalo Gap, Saskatchewan; and d) Simpson P.O., Kentucky. The moisture maximized amount for Buffalo Gap of 16.3 in. exceeds the value interpolated from figure 24 of 14.4 in. for the northern Great Plains, the region within which it could be transposed. However, the moisture maximization factor for this storm is 155 percent. Since this moisture maximized value is not supported by the values for other storms in the region, we have adopted the convention of limiting the adjustment factor to 150 percent.

The Buffalo Gap observation is based upon a D.A.D. analysis of the results of a bucket survey. Figure 24 "undercuts" the moisture maximized transposed value by about 1 in. and is about 4 in. larger than the observed precipitation value. Considering all the uncertainties involved, we feel this is a reasonable estimate of the 1-mi^2 1-hr PMP for this region, and that it is comparable to practices followed in HMR No. 51. (See section 4.1 of that report.)

In figure 25, the moisture adjustment factor used for the Cherry Ck. storm is 122 percent. (This percent was also used for the Hale center of the same storm listed in HMR No. 51.) Recently, the dew point for this storm was reevaluated

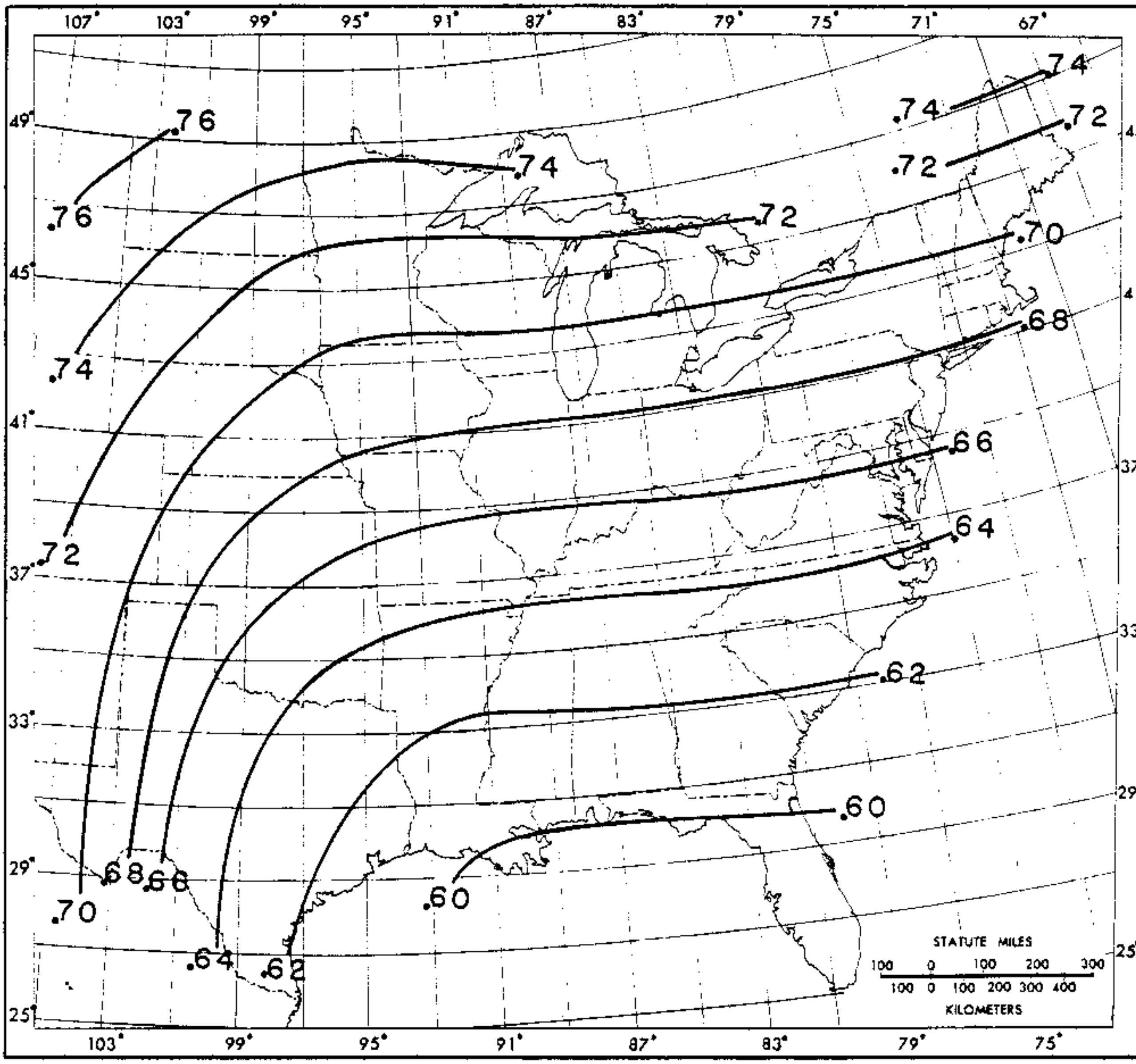

Figure 23.--1-hr pt. to 6-hr 10-mi^2 ratio of precipitation based on major storms used in HMR No. 51 and rainfall frequency studies.

and resulted in a revised moisture adjustment factor of 141 percent. Applying this new adjustment factor to the 1-hr value for the storm gives a maximized value of 15.5 in., which more closely supports the 16.7 in. value interpolated from figure 24.

The moisture adjusted values show little support for the values shown in the southern portion of the 1-hr 1-mi^2 PMP map. The next step in the traditional method for developing PMP values would be transposition of the maximized amounts within regions of meteorological homogeneity for each extreme storm of record. Figure 26 shows the transposition limits for the Smethport, Pennsylvania storm of July 17-18, 1942, the moisture maximized value at the storm location, and the moisture maximized transposed value for the southwestern extreme of the

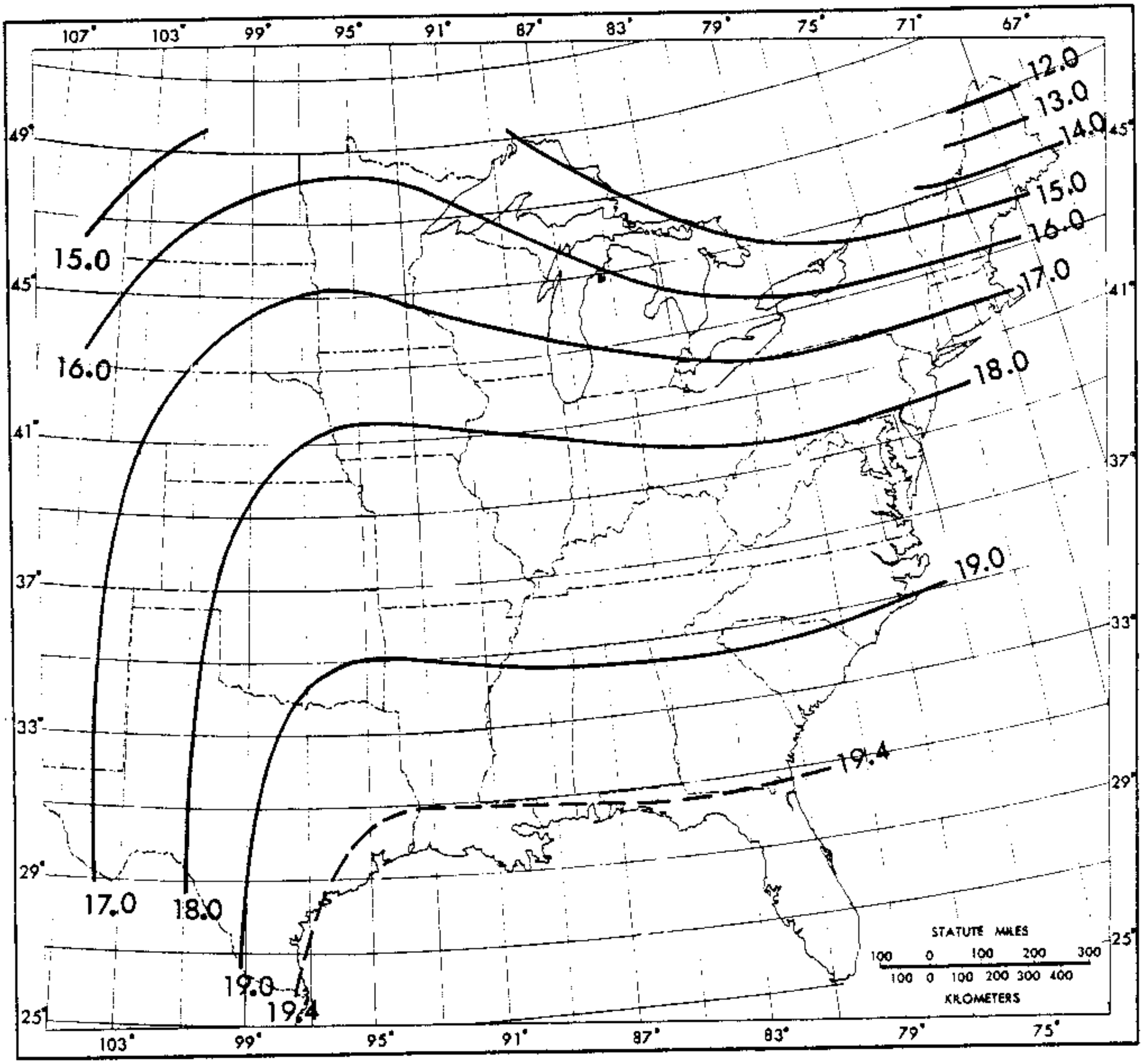

Figure 24.—1-hr 1-mi^2 PMP analysis based on figure 23 and 6-hr 10-mi^2 precipitation from HMR No. 51.

transposition limits. Comparison of this 18.3-in. value with the 1-hr 1-mi^2 PMP from figure 24 shows a difference of 0.6 in. We consider this a reasonable envelopment of a moisture maximized transposed amount.

6.3.3 Depth-area ratios

Preparation of 1-hr PMP values over the range of area sizes of interest required development of depth-area reduction ratios. A primary basis for such reduction ratios is the list in table 19 of 12 extreme storms (those noted by asterisks) for which point or 1-mi^2 data are available at 1 hr. A problem with the data from these 12 storms is the limited area of most storms. Nearly 60 percent have an areal extent of less than 240 mi^2, while one fourth of them

Table 21.—Extreme 1-hr amounts used as support for 1-hr 1-mi^2 PMP map

Location of storm center									
	Lat.		Long.		Date	Storm assignment	1-mi^2 amt.		Remarks
Nearest station	(°)	(')	(°)	(')		number+	6-hr	1-hr	
Elbert, CO (Cherry Ck.)#	39	13	104	32	5/30-31/35	MR 3-28A	24.0	11.0	Estimated from mass curves prepared for storm study. Same value determined for several stations.
Woodward Ranch, TX	29	20	99	18	5/31/35	GM 5-20	21.0	9.3	Pertinent data sheet for storm study published in "Storm Rainfall" (U.S. Army Corps of Engineers 1945 -).
Simpson P.O., KY	38	13	83	22	7/4-5/39	OR 2-15	20.0*	13.4*	From reconstructed depth-duration curve.
Smethport, PA	41	50	78	25	7/17-18/42	OR 9-23	30.7	15.0	From mass curve for station with maximum observed storm amount. Mass curve constructed using recorders about 4 mi away. Original bucket survey data used to aid in analysis.
Holt, MO	39	27	94	20	6/18-23/47	MR 8-20	12.0	12.0	Published bucket survey data indicates amount at maximum station in primary burst occurred in 42 min.
Cove Creek, NC	35	36	83	01	6/30/56	---		10.12	See Schwarz and Helfert (1969). We adopted 11.0 as an appropriate value to use in these comparisons.

Table 21.—Extreme 1-hr amounts used as support for 1-hr 1-mi^2 PMP map - Continued

Location of storm center						Storm			
	Lat.		Long.		Date	assignment	1-mi^2 amt.		Remarks
Nearest station	(°)	(')	(°)	(')		number+	6-hr	1-hr	
Buffalo Gap, Saskatchewan, Can.	49	07	105	18	5/30/61	SASK - 5-61†		10.5	From depth-area-duration curves published in Canadian Storm Rainfall†.
Glen Ullin, ND	47	21	101	19	6/24/66	--	12.16	7.89	From pertinent data prepared by USBR.
Enid, OK	36	25	97	52	10/10-11/73	--	16.9	6.7	From mass curve developed for station with maximum storm total. Mass curve modeled on data from NWS station at Enid, OK. Enid station was approximately 6 mi from maximum observed amount.

* 10-mi^2 amount
\+ See table 19
† Assignment number from "Canadian Storm Rainfall" (Canadian Dept. of Transport; ongoing publication)
\# See note for table 20

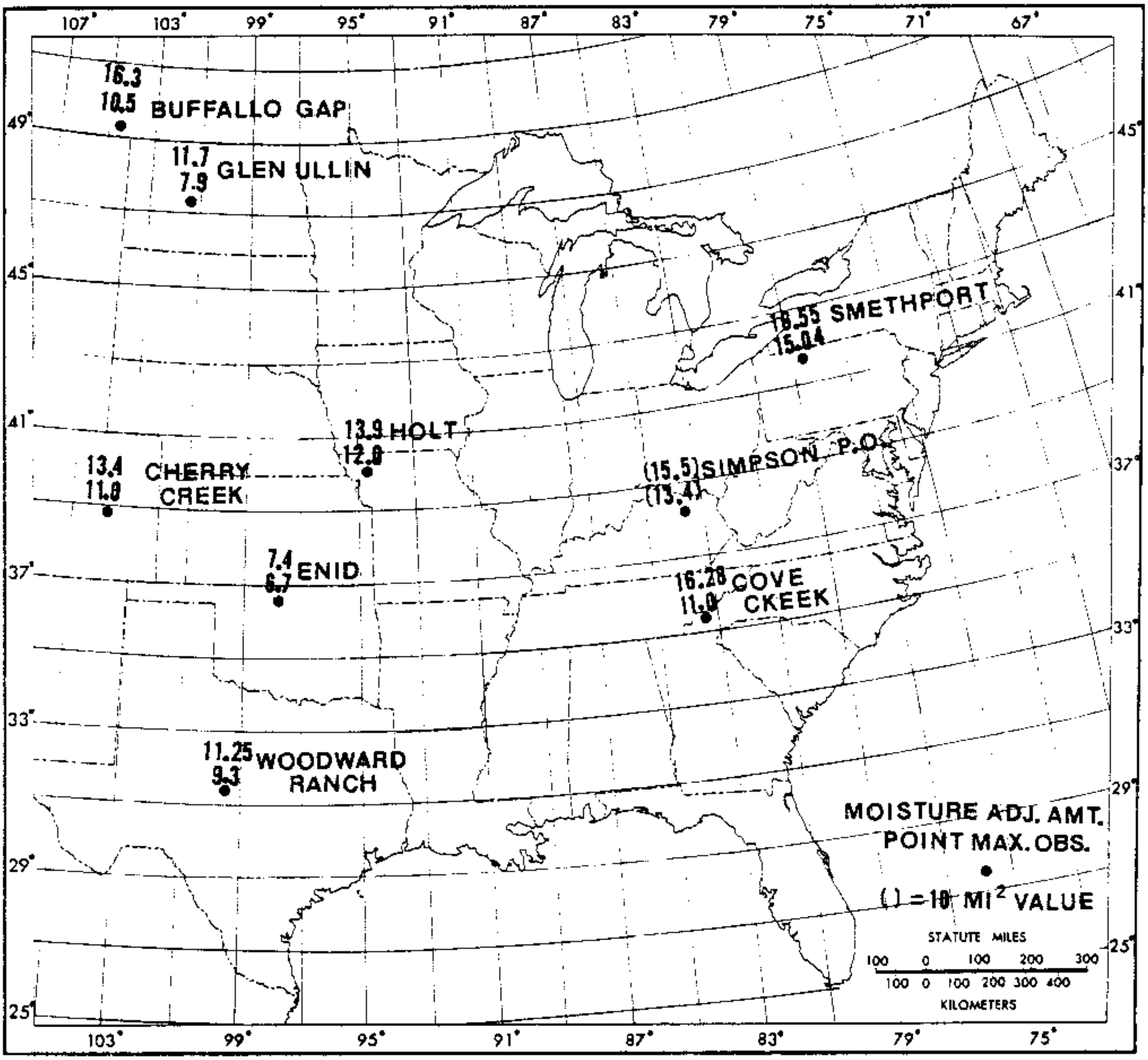

Figure 25.—Maximized observed 1-hr point amounts and moisture maximized values from major storms listed in table 21.

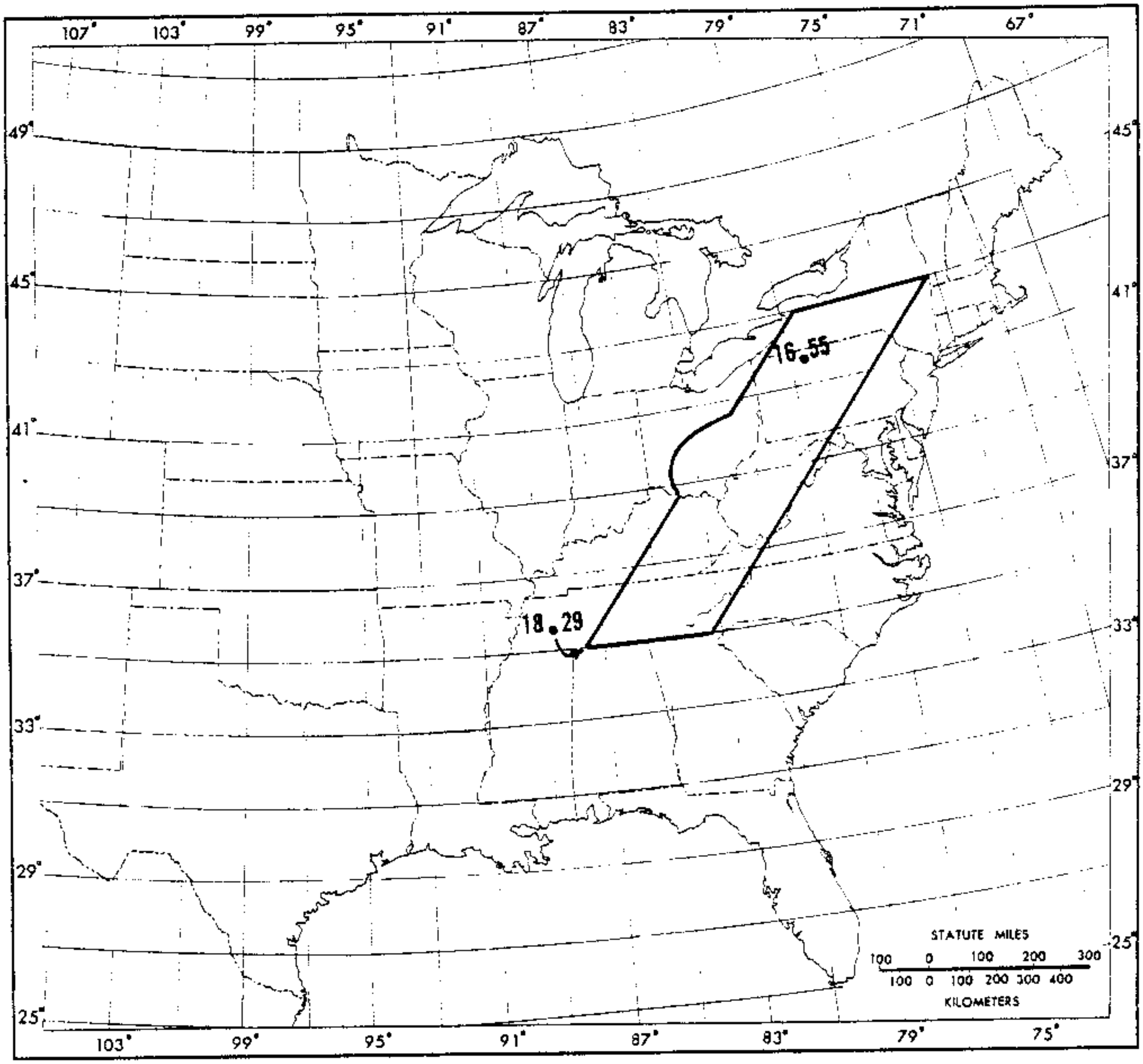

Figure 26.—Example of transposition limits as applied to the Smethport, PA storm (7/17-18/42).

enclose an area less than 100 mi^2. It was decided to develop an average depth-area curve for the 1-hr duration from these 12 storms and similar curves for the 6- and 12-hr durations from these storms and 9 additional storms from the 54 storms for which maximum point or 1-mi^2 amounts were available (table 20). The curves for the 6- and 12-hr durations were used as an aid in shaping the 1-hr curve for the larger area sizes. Figure 27 shows the data for these 12 storms for the areas of 600 mi^2 and less and the curve of best fit for the data. Similar curves (not shown) were drawn for the 6- and 12-hr durations.

The depth-area relations implicit in the set of PMP values derived from the maps of HMR No. 51 represent enveloping values from a combination of storms. We therefore adjusted our family of curves to be compatible with an average depth-

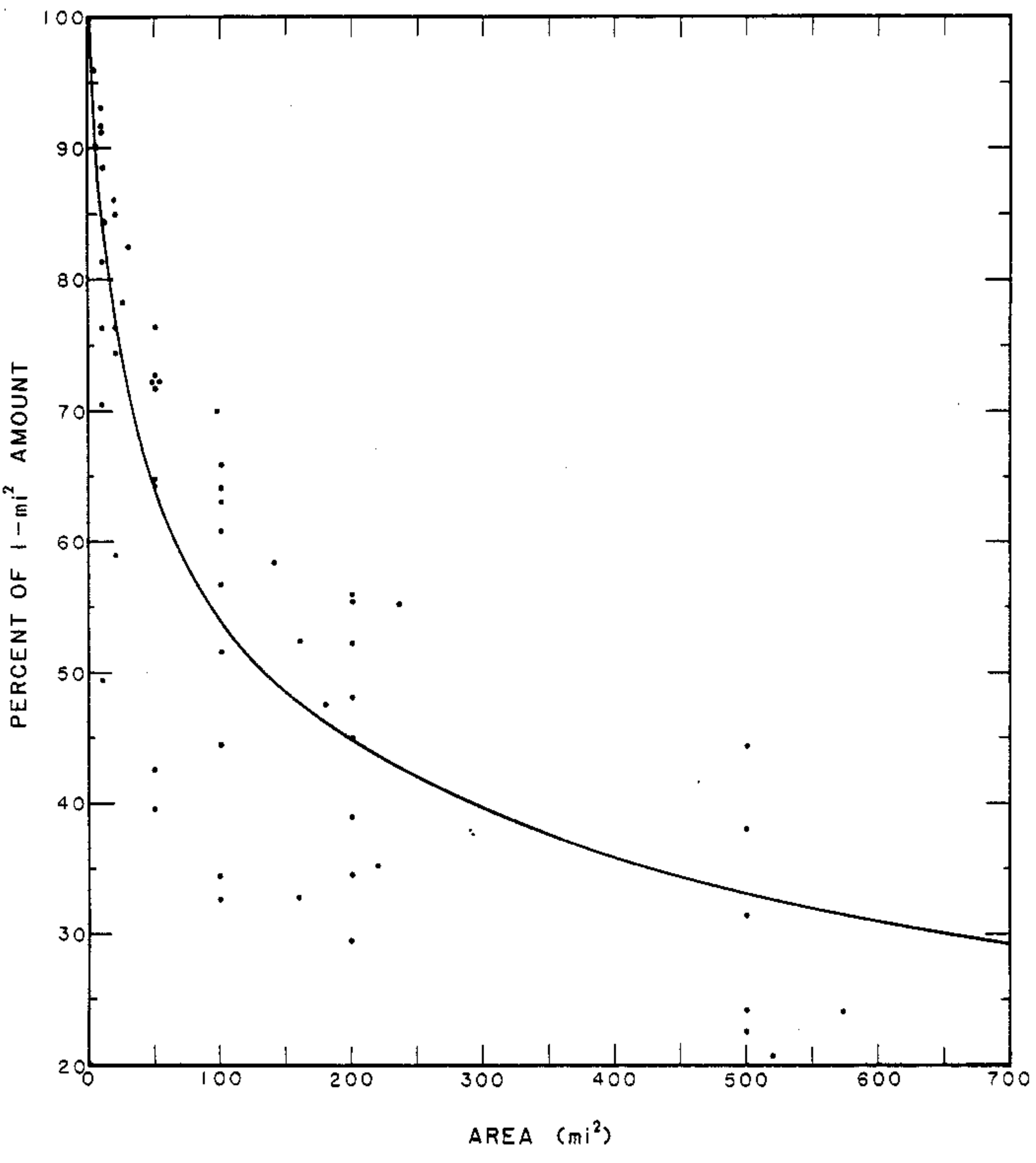

Figure 27.—Depth-area data plotted as percent of maximum 1-hr 1-mi^2 amount for storms where the maximum 1-hr 1-mi^2 amount was determined from a dense network of observations or bucket survey amounts.

area reduction curve developed using PMP values from HMR No. 51. Although some regional variation was seen in curves developed at a number of widely spaced geographic locations, it was decided that one curve would be adequate for the 1-hr duration. We think this is realistic, since the regional variation was just slightly less at 6 hr than at 12 hr, and it is meteorologically reasonable to expect the potential for shorter durations to be less variable throughout the region than it is for the longer durations. The rationale here is that a longer duration storm (>24 hr) requires a sustained moisture inflow that is most likely to occur nearest the coast and decreases inland. This contrasts with the moisture requirements for a short-duration local storm which is likely to occur almost anywhere. The adopted 1-hr depth-area curve, in percent of the 1-mi^2 PMP, is shown in figure 28. This curve covers area sizes as large as 20,000 mi^2 and was determined primarily to provide areal 1-hr values that enveloped available data. Since most of the available data are from small area storms (<500 mi^2), there is less reliability with increasing area size. Nevertheless, 1-hr 20,000-mi^2 data are available for the Bonaparte, Iowa storm (6/9-10/1905), which provided a large-area check of the adopted depth-area relation.

6.3.4 1-hr PMP for areas to 20,000 mi^2

The depth-area curve developed in the preceding section (fig. 28) was used to compute PMP for 10, 100, 200, 1,000, 5,000, 10,000 and 20,000 mi^2 (figs. 29 to 35, respectively).

The four storms (see section 6.3.4) which provide significant support for the 1-mi^2 1-hr PMP also provide evidence of the reasonableness of the PMP values for these larger areas. In addition, the moisture maximized value for Cherry Ck., Colorado is within 15 percent of the PMP at the storm location. The moisture maximized value for the Simpson, P.O., Kentucky storm exceeds the estimated PMP at the storm location by 0.4 in. for 10 and 100 mi^2. At 200 mi^2, the PMP and the moisture adjusted value for Simpson are about equal. Since the 1-hr amount was determined from a reconstructed depth-duration curve, it was decided not to revise the PMP estimate based on this difference.

6.4 PMP for Durations Less Than 1-hr

As mentioned in section 6.2, there are no storm studies that have data for durations less than 1 hr. The very-short duration data most nearly representative of extreme storm situations can be found in the excessive precipitation tablulations published in "Climatological Data" (National Weather Service, 1914-). A series of the maximum annual values was determined for each duration of interest for every station in the east where such data are available. These data were examined to see if there was any trend for higher or lower ratios with the magnitude or recurrence intervals. The data indicate that the ratios have a slight tendency to decrease with increasing magnitude. There is also a slight geographic variation with the ratios with decreasing latitude. These trends have been incorporated into the appropriate ratio maps. Only one set of ratio maps (relative to 1 hr) have been provided, figures 36, 37, and 38 for the 5-, 15-, and 30-min durations, respectively.

Since there are no data from which to develop areal corrections, we apply the same ratio for all areas. It is for this reason that we feel values for these shorter durations should be be limited only to area sizes of 200 mi^2 or less.

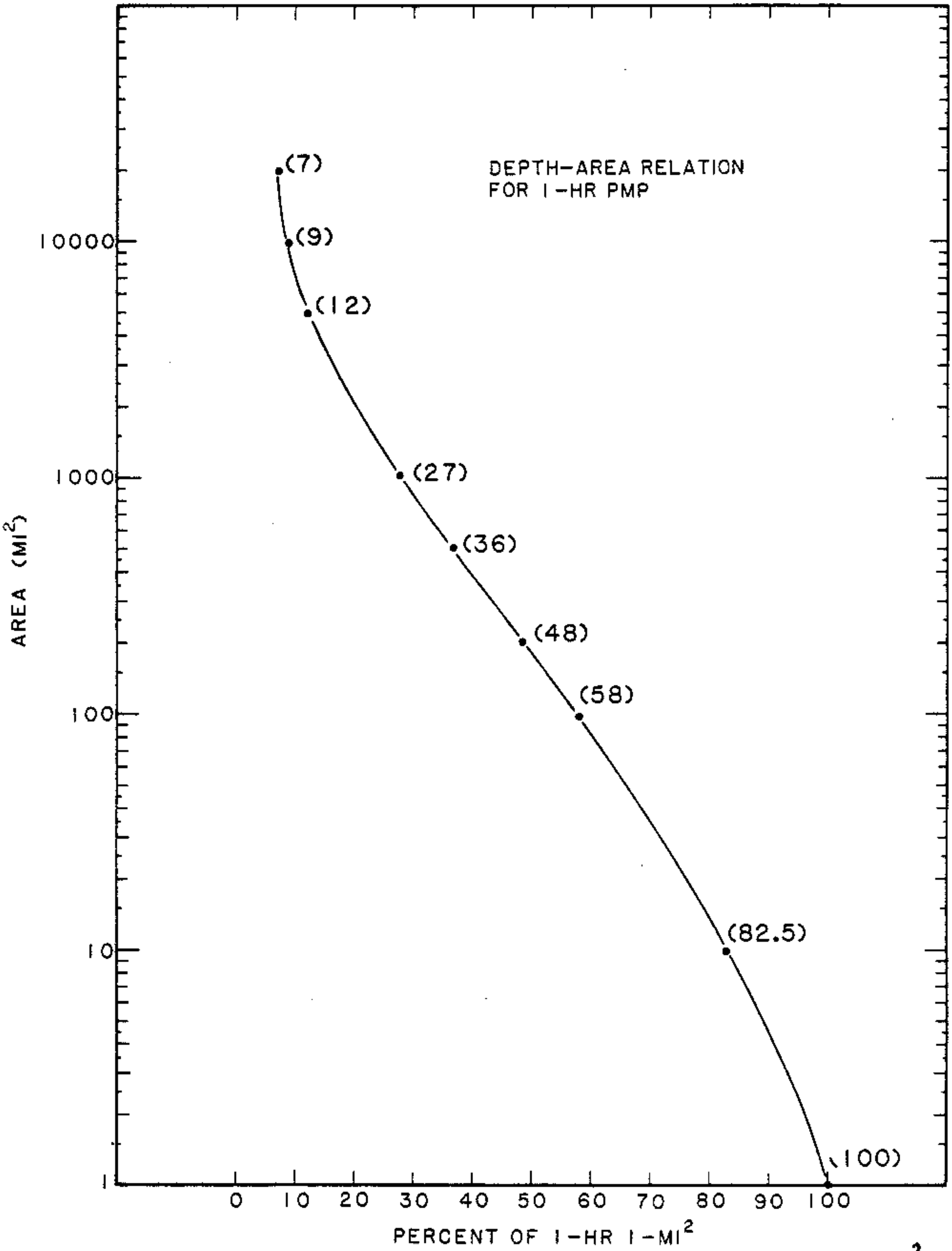

Figure 28.—Depth-area relation for 1-hr PMP in percent of maximum point (1-mi^2) amount.

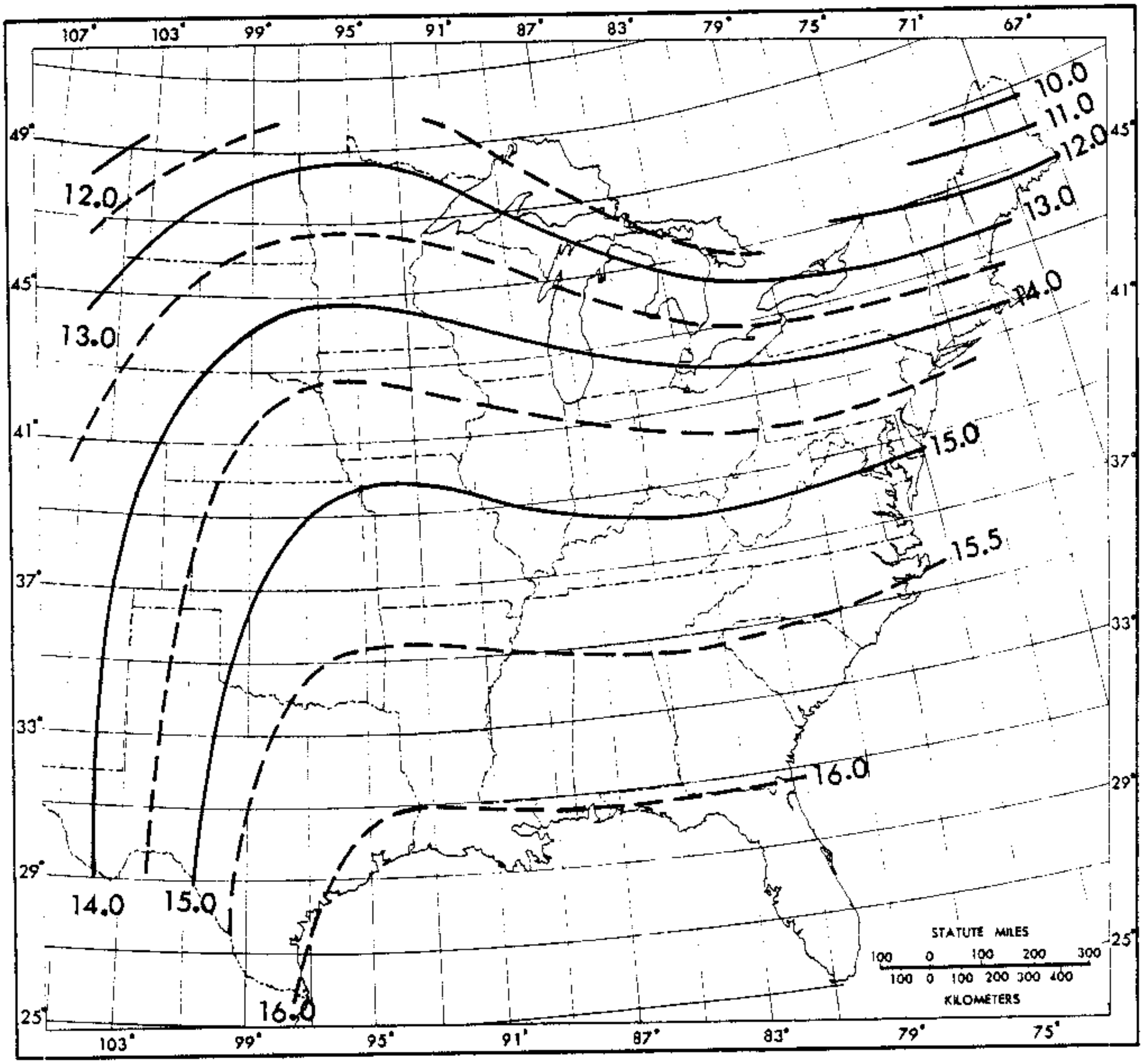

Figure 29.--1-hr 10-mi^2 PMP analysis for the eastern United States.

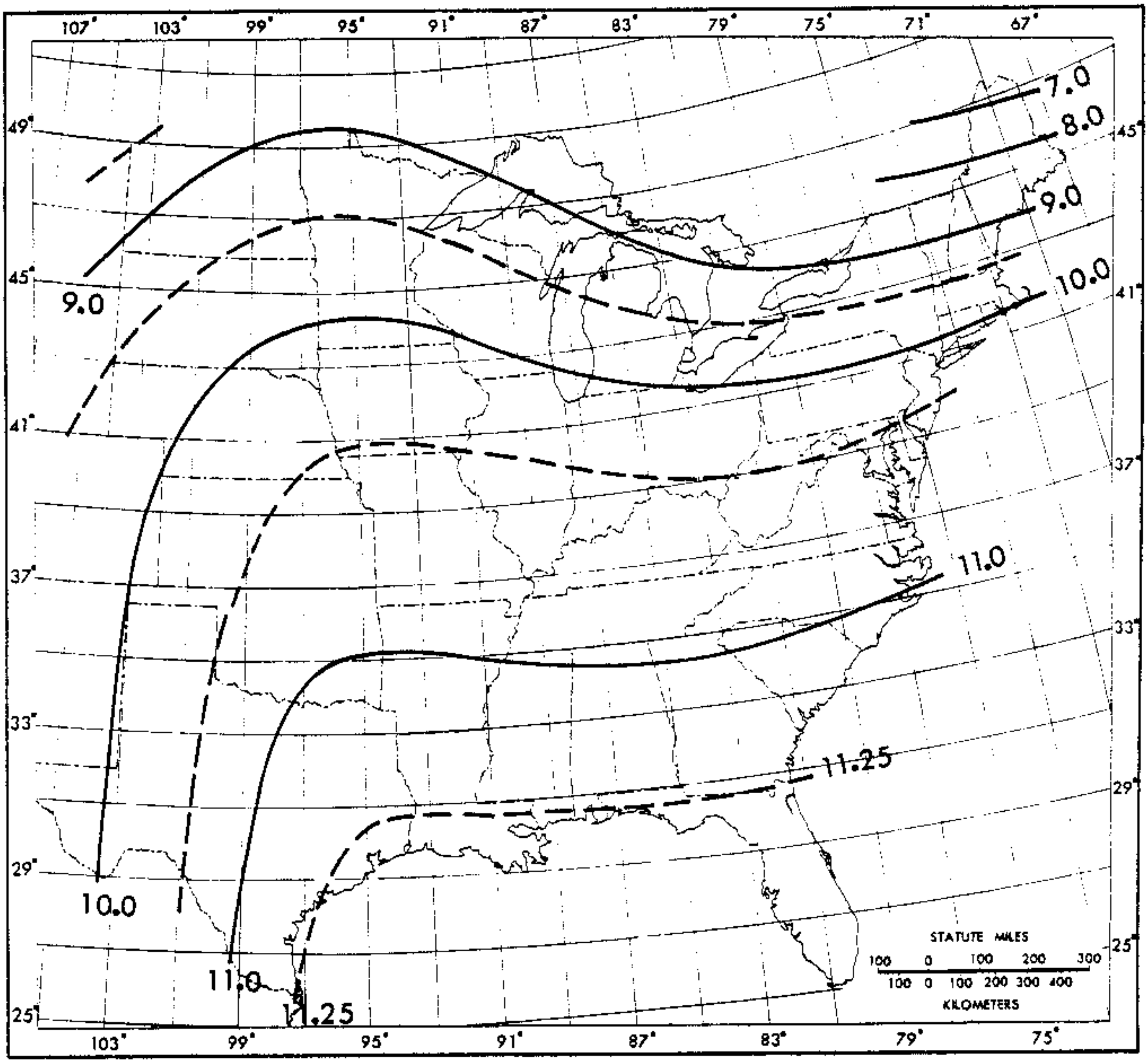

Figure 30.—1-hr 100-mi^2 PMP analysis for the eastern United States.

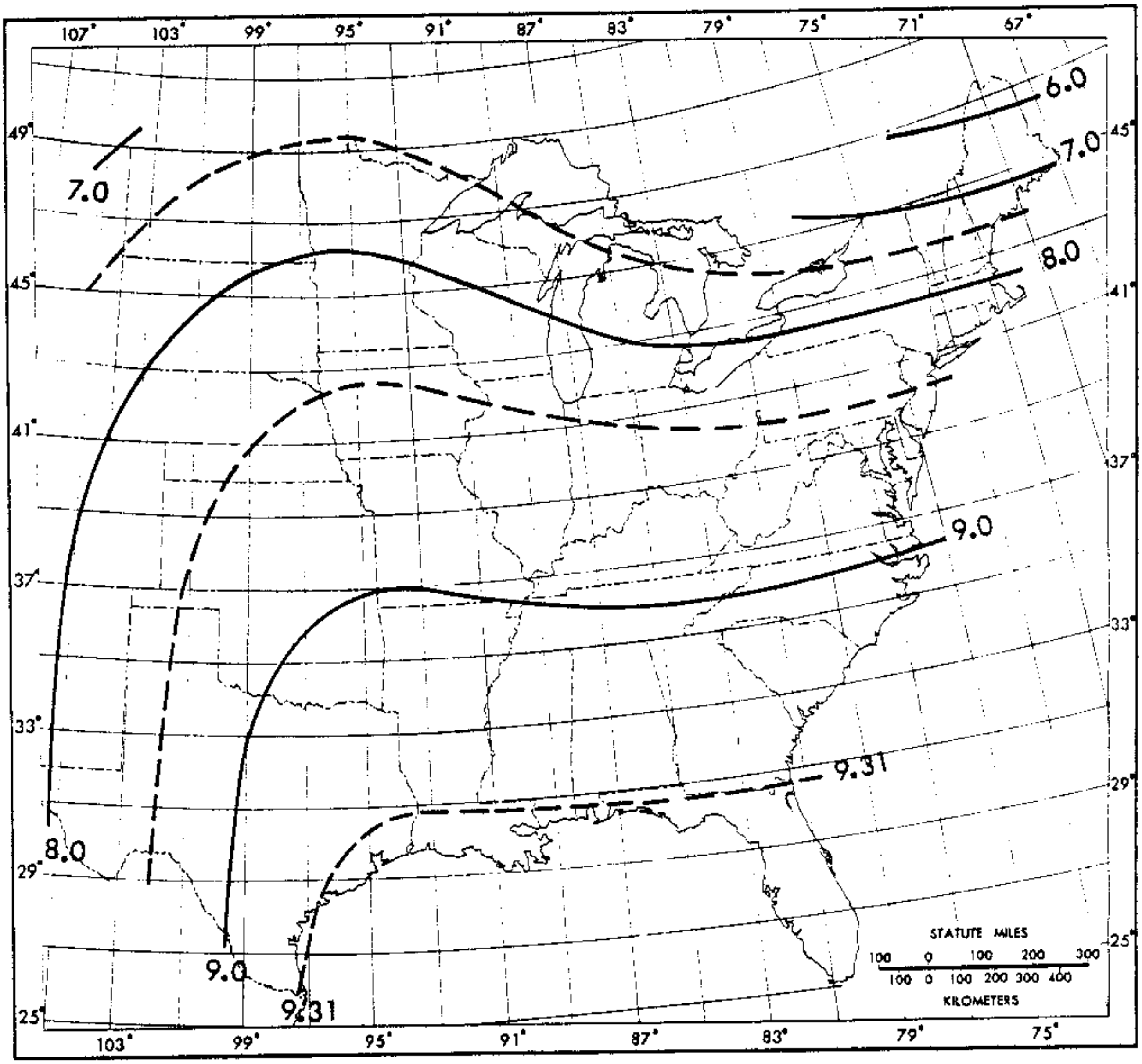

Figure 31.—1-hr 200-mi^2 PMP analysis for the eastern United States.

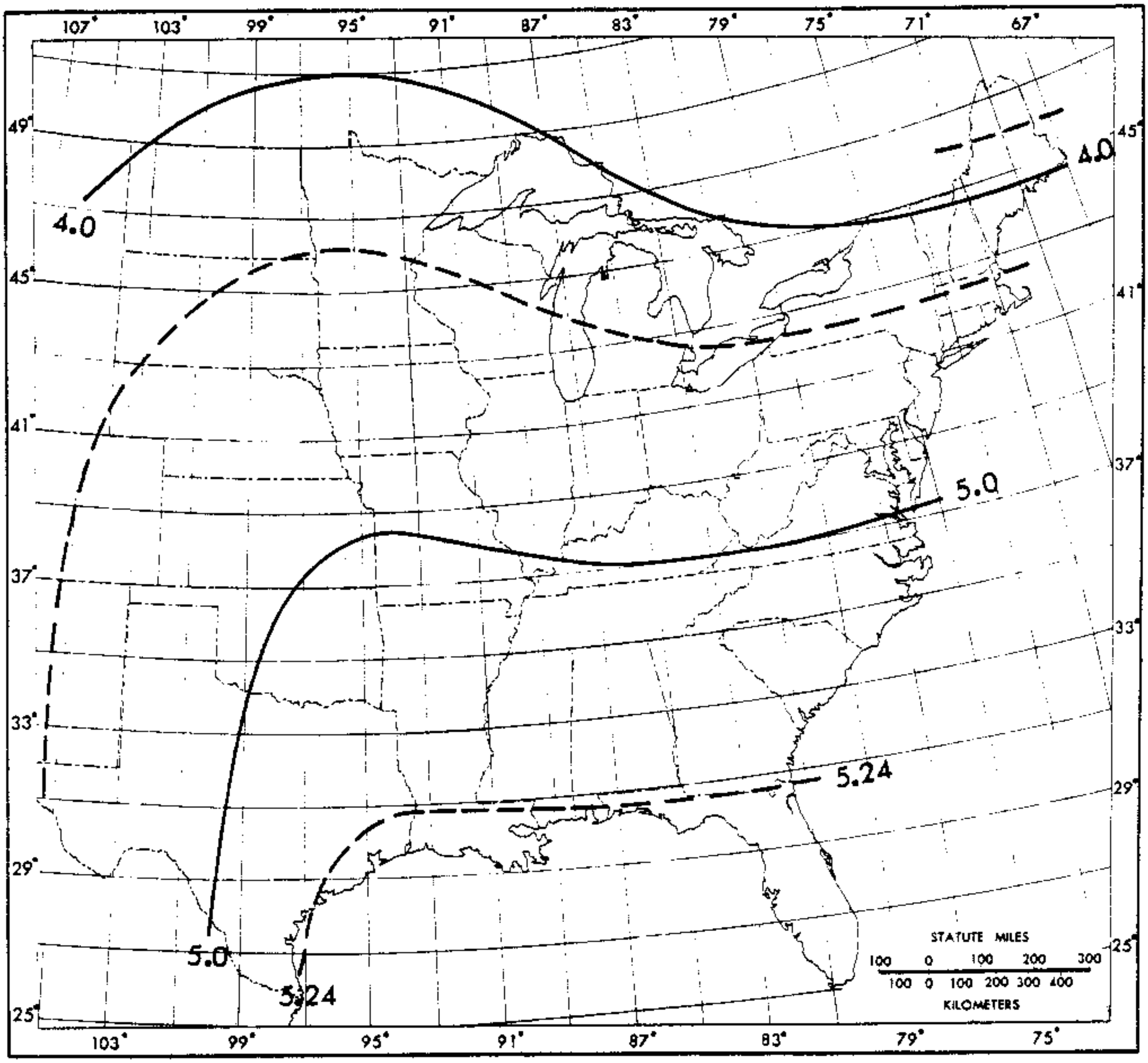

Figure 32.—1-hr 1,000-mi² PMP analysis for the eastern United States.

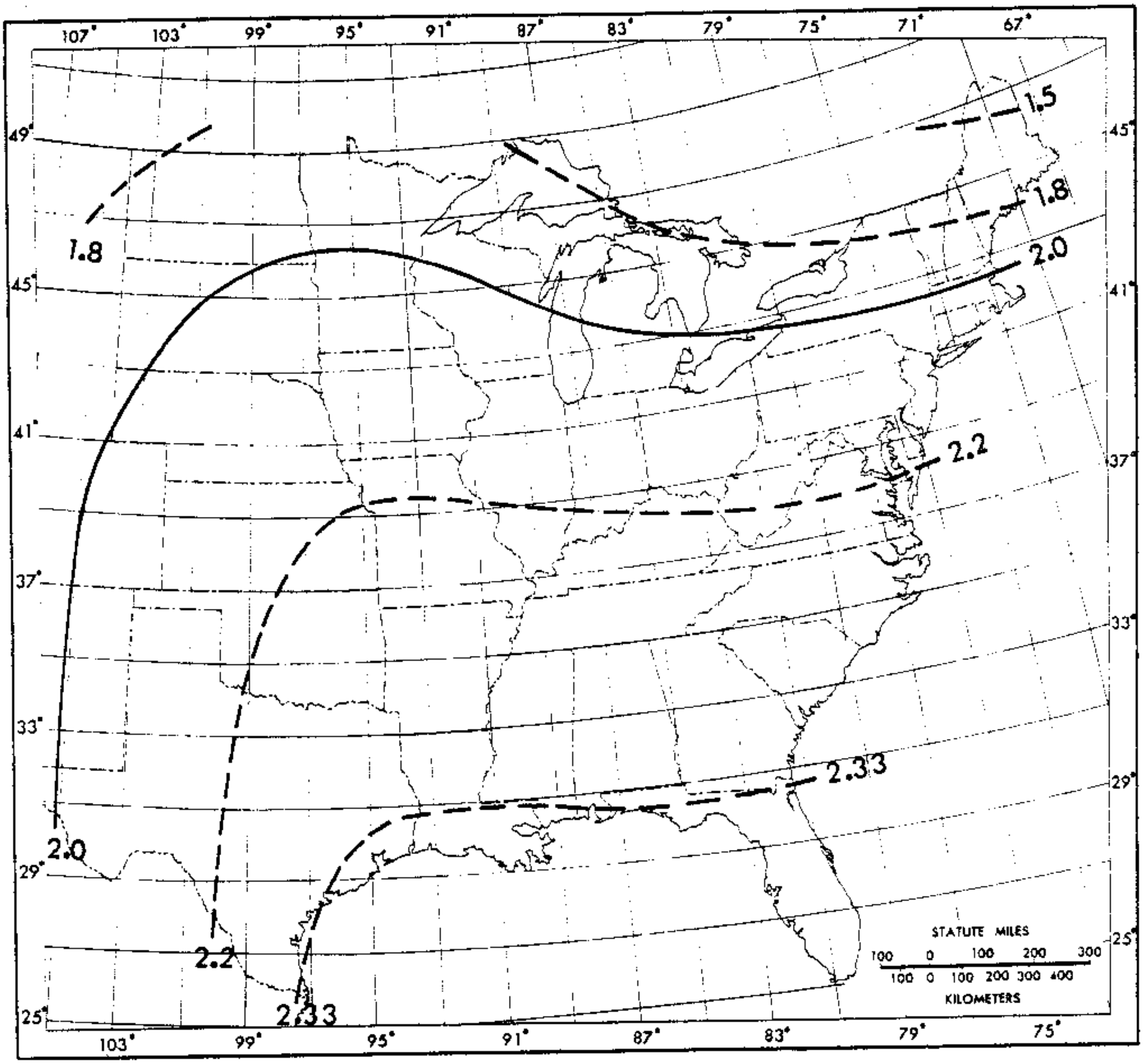

Figure 33.—1-hr 5,000-mi^2 PMP analysis for the eastern United States.

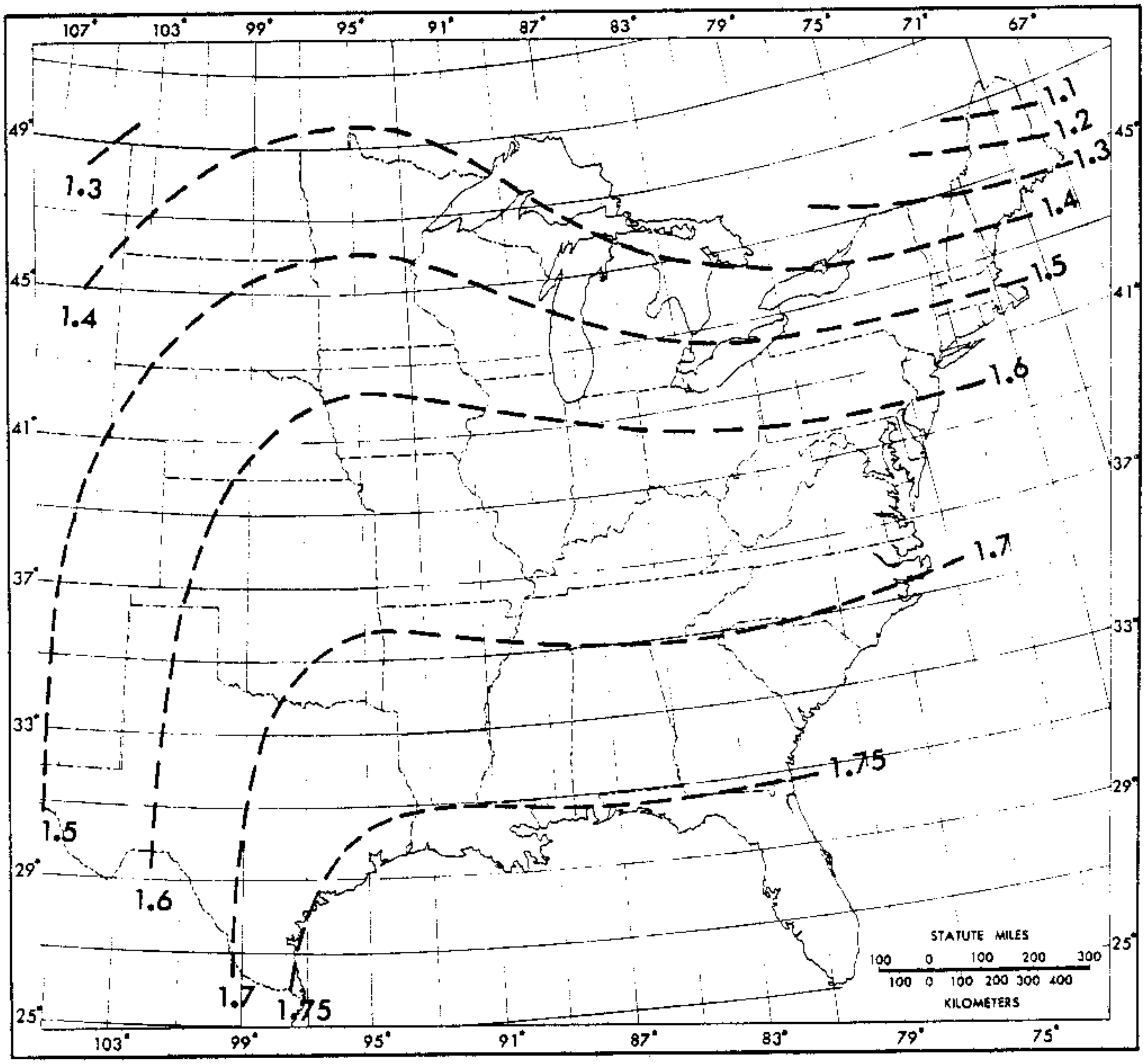

Figure 34.—1-hr 10,000-mi^2 PMP analysis for the eastern United States.

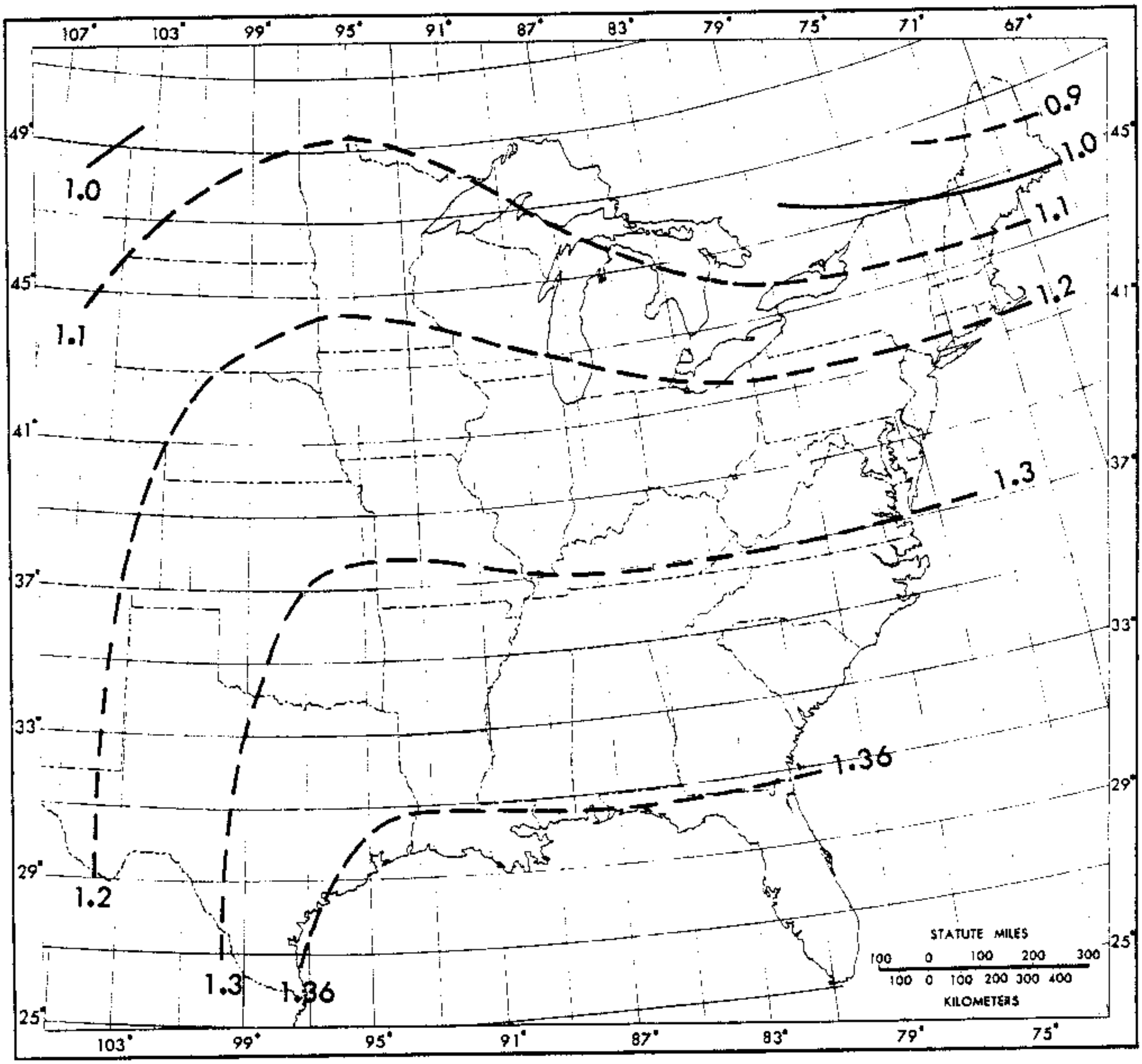

Figure 35.--1-hr 20,000-mi^2 PMP analysis for the eastern United States.

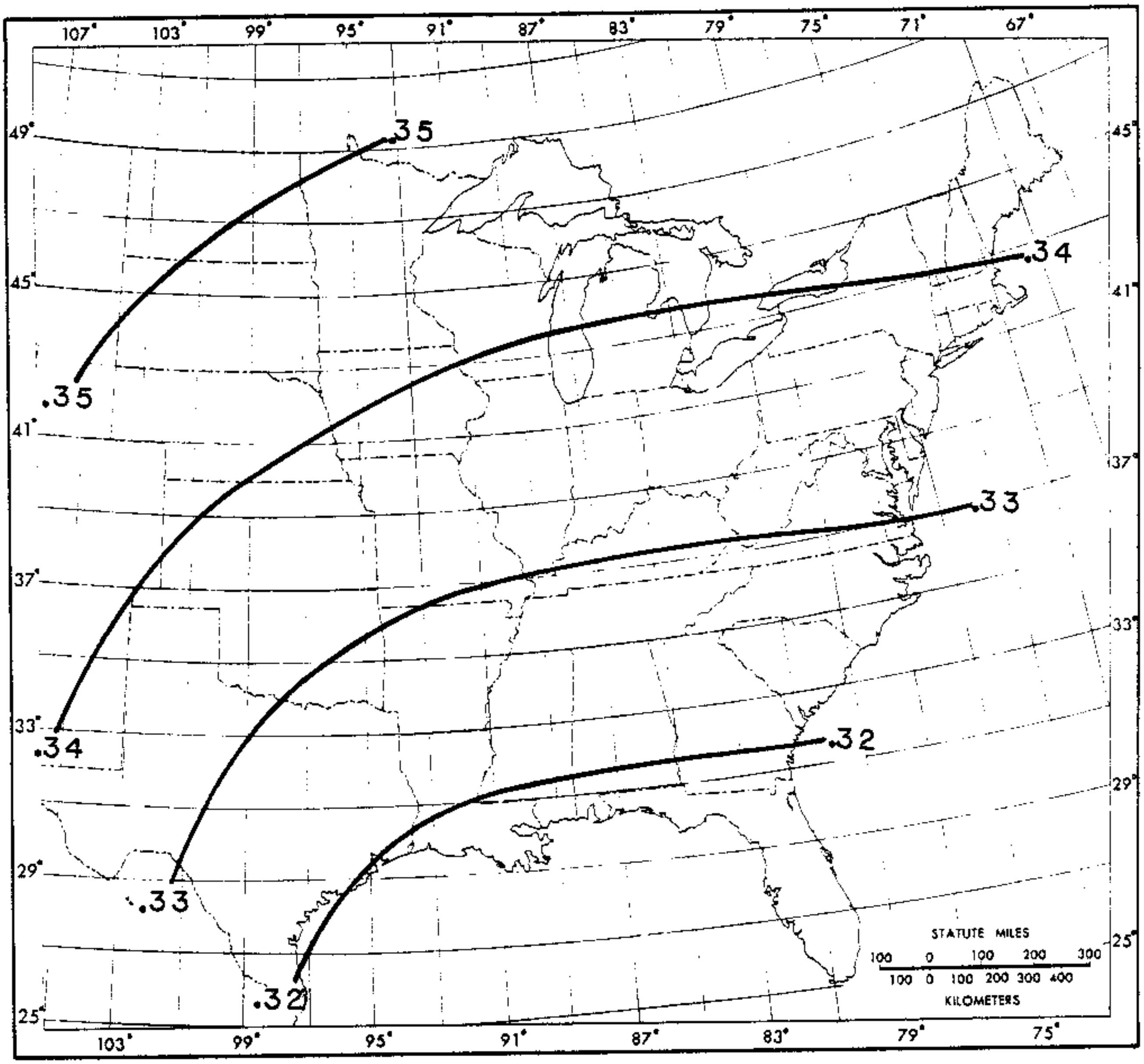

Figure 36.--Ratio analysis of 5- to 60-min precipitation used to obtain 5-min PMP. (Applicable to area sizes < 200 mi^2.)

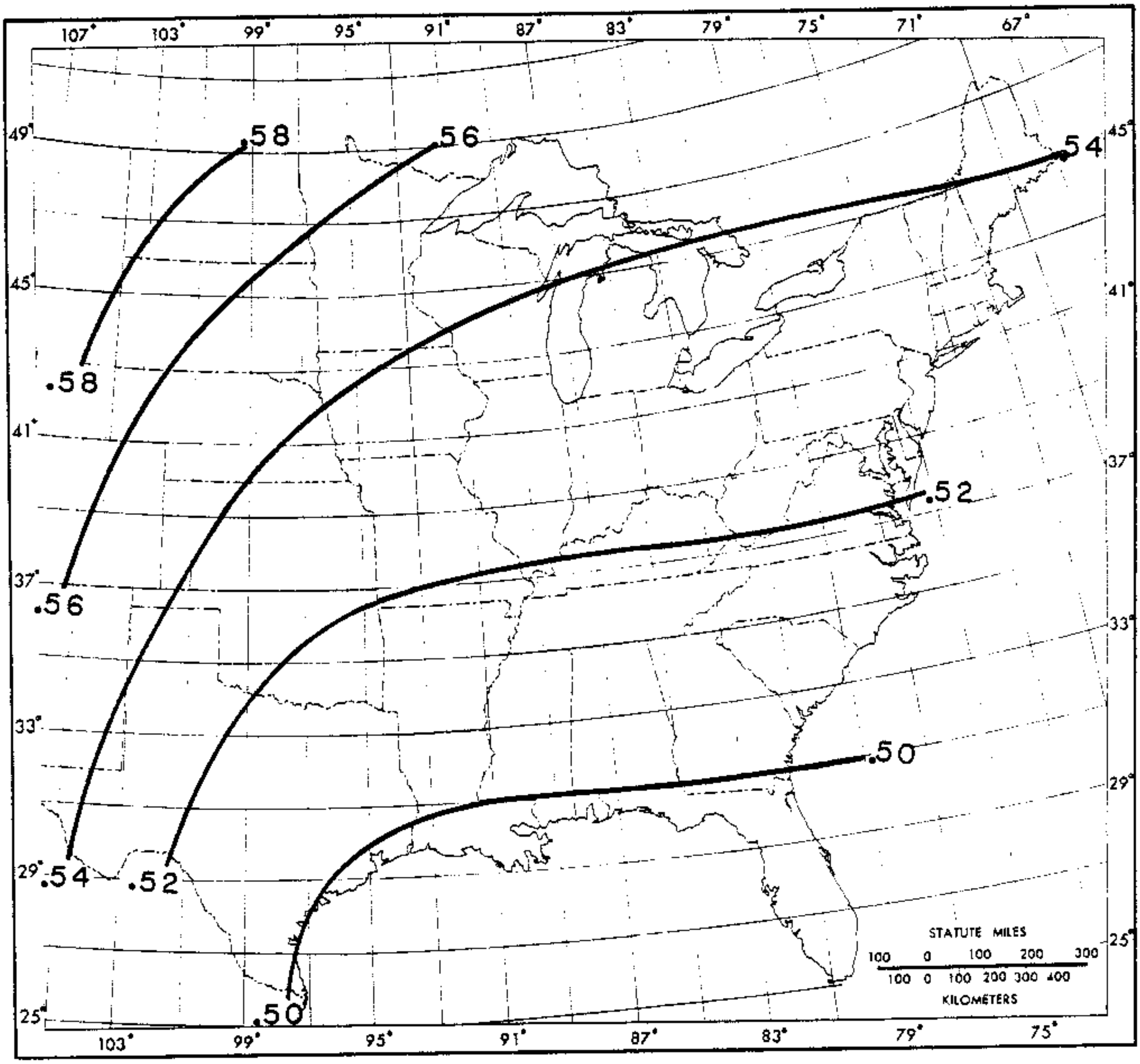

Figure 37.—Ratio analysis of 15- to 60-min precipitation used to obtain 15-min PMP. (Applicable to area sizes < 200 mi^2.)

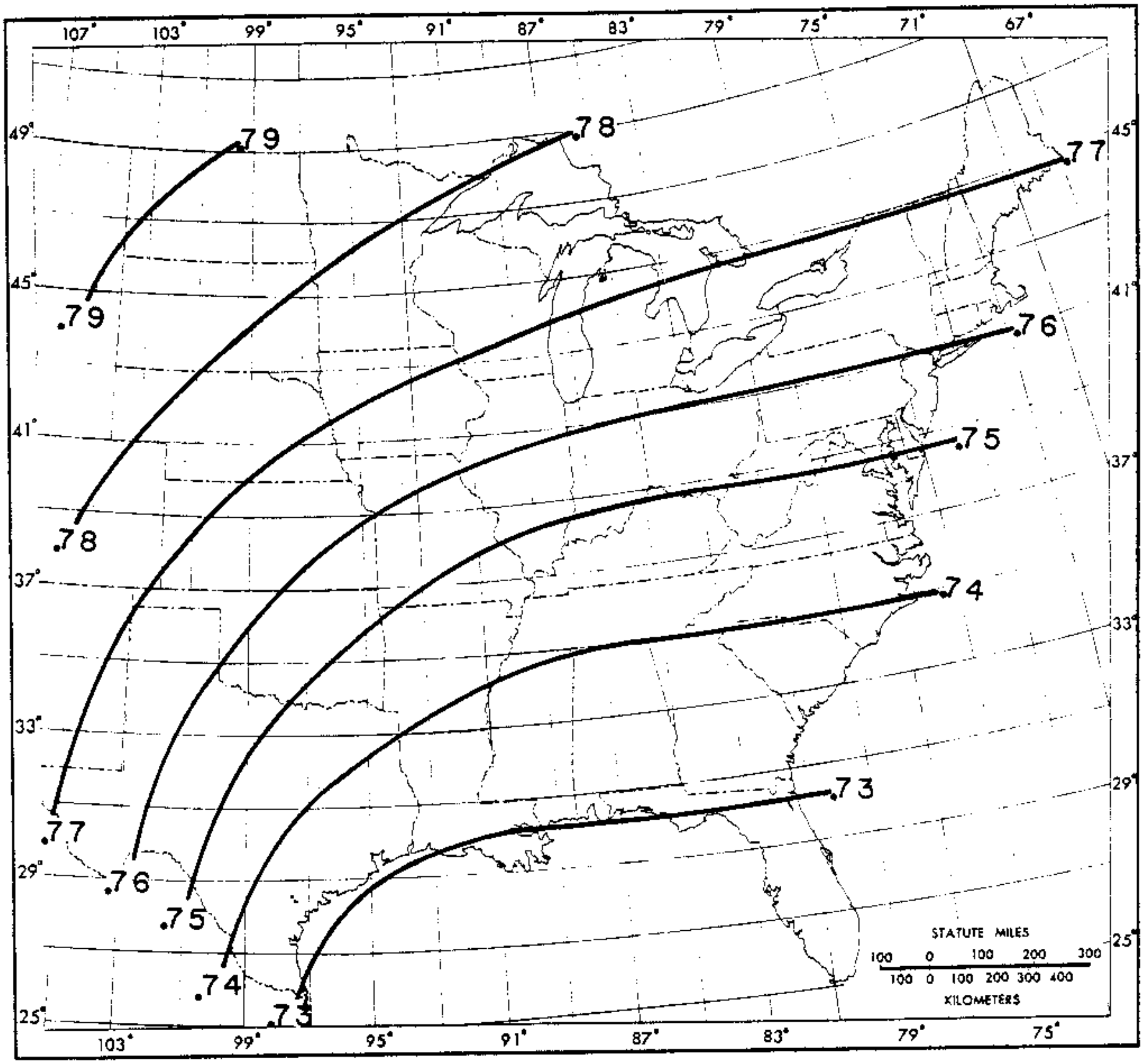

Figure 38.—Ratio analysis of 30- to 60-min precipitation used to obtain 30-min PMP. (Applicable to area sizes < 200 mi^2.)

6.5 Isohyet Values for Durations Less Than 1-hr

As in chapter 5, where a procedure was given to compute isohyet values for each 6-hr isohyetal pattern of the 72-hr PMP, it is also important to provide a procedure to distribute the precipitation for durations within the greatest 6-hr increment. Such information has not been included in any previous study. Also, since little depth-duration data were available for the durations less than 6 hr in the major storms, it was not possible to pursue an approach similar to that used in chapter 5. Furthermore, one finds that by plotting the isohyet values for each 6-hr period, it is possible to fit the short durations (<6 hr) by any number of smooth curves. Especially for large values of 6-hr PMP the depth-duration relation for durations less than 6 hr has the greatest curvature and therefore the greatest flexibility in curve fitting, depending upon the individual analyst. As a consequence, a procedure was adopted that allowed answers to be obtained with an accuracy of ± 10 percent. This tolerance was judged acceptable considering the approximations involved in the procedure.

Sections 6.5.1 and 6.5.2 describe the procedure to obtain isohyet values for isohyets in the PMP portion of the pattern as applied to short durations within the greatest 6-hr increment. Residual isohyet values are discussed in section 6.5.3. The discussion and example in chapter 7 are meant to further clarify the application of this procedure.

6.5.1 Description of procedure

Only a brief description of the procedure has been provided here. Following the procedure in chapter 5, it is possible to determine the isohyet values for the greatest 6-hr increment relative to a specific drainage application. It was noted in some sample applications that the 6/12-hr ratios obtained for each isohyet decreased with increasing isohyets (area). This result implies that the 1/6-hr or 15-min/6-hr ratios will also vary between isohyets. The adopted procedure recognizes this variation and was developed as follows. Depth-duration curves were drawn for each isohyet from data for the 4 greatest 6-hr increments of PMP. Values for 1 hr were interpolated from these curves and 1/6-hr ratios determined. These ratios were plotted against area size (area enclosed by respective isohyets) and a smooth curve drawn through the points. A comparison was then made by computing the area-averaged precipitation obtained from distributing the precipitation according to the smooth curve and determining the area-averaged depth taken directly from the D.A.D data based on figures 24, and 29 to 35. The smooth curve was then adjusted to correct for any discrepancies.

Determining the ratio curves at a number of locations throughout the region and for a number of pattern area sizes showed a regional and areal variation in the results. To account for the regional variation, it was decided to prepare an index map for the 1-hr 20,000-mi^2 ratios of the 6-hr labels for the A isohyet. This particular choice was based on a number of trials and this area size was selected because it had the greatest regional variation. Figure 39 shows the 1/6-hr ratio index map. In this map the ratios increase from the southeast to the northwest through most of the region.

To show the areal variation, a regionally averaged nomogram was developed, as shown in figure 40. The abscissa is based on a scale of percent of the corresponding 6-hr isohyet value. It was necessary to omit every other isohyet (B, D, F, H) from these nomograms for clarity, but simple interpolation will

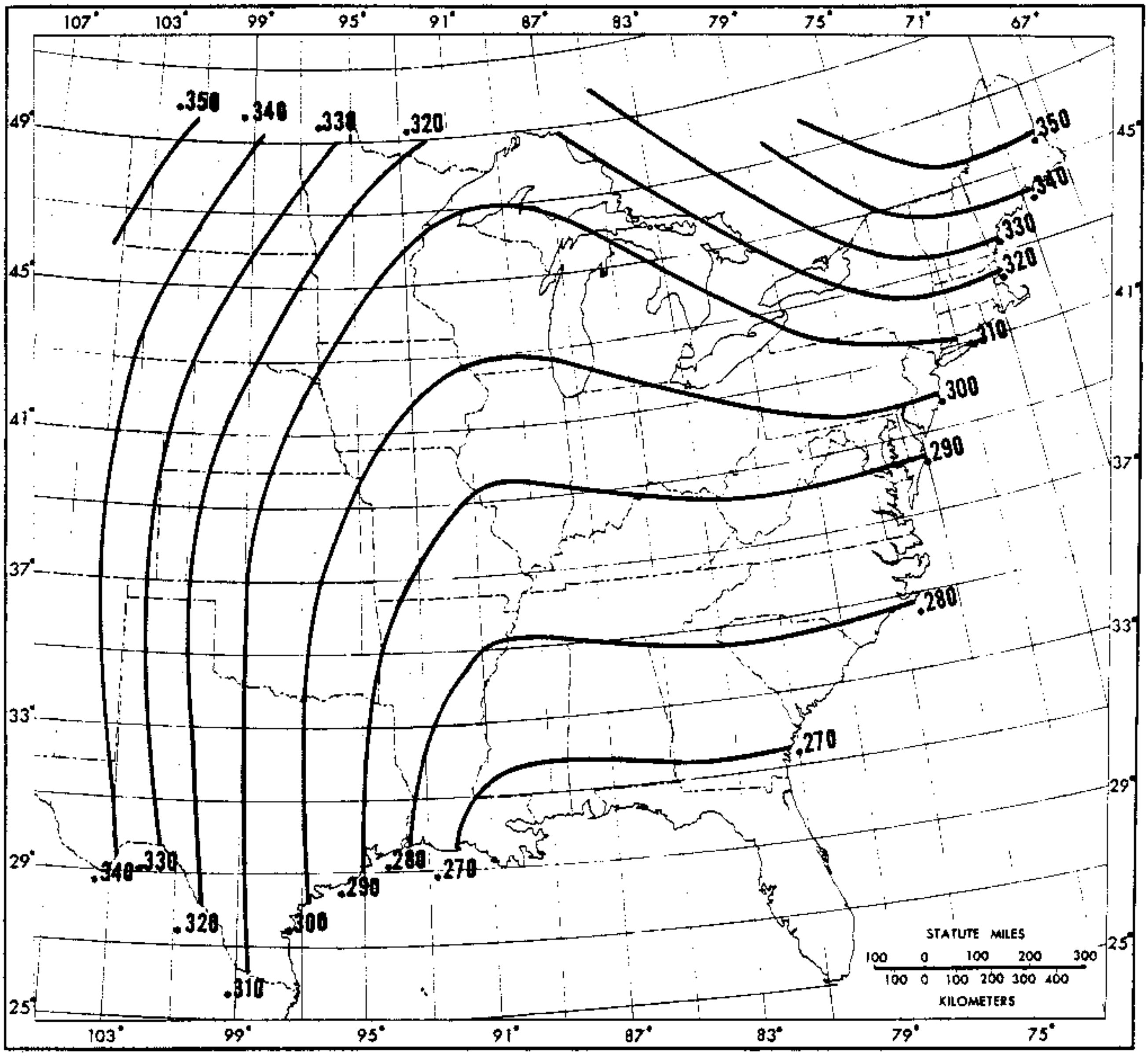

Figure 39.—Index map for 1- to 6-hr ratios for 20,000-mi^2 "A" isohyet.

provide values for the missing isohyets. The nomogram does not include information for the residual isohyets.

6.5.2 Application of nomogram for short duration isohyets

The use of the relations in figure 40 is simple. One locates the center of the drainage being considered (for which 6-hr isohyet values have been determined as directed in chapter 5) on figure 39 and interpolates the 1/6-hr ratio. This ratio then represents the label of the 1-hr 20,000-mi^2 A isohyet on the nomogram in figure 40. The user must then make a copy of the scale provided with the nomogram and place the scale on the nomogram to correspond to the value determined from the index map. Having adjusted the scale, all isohyet values

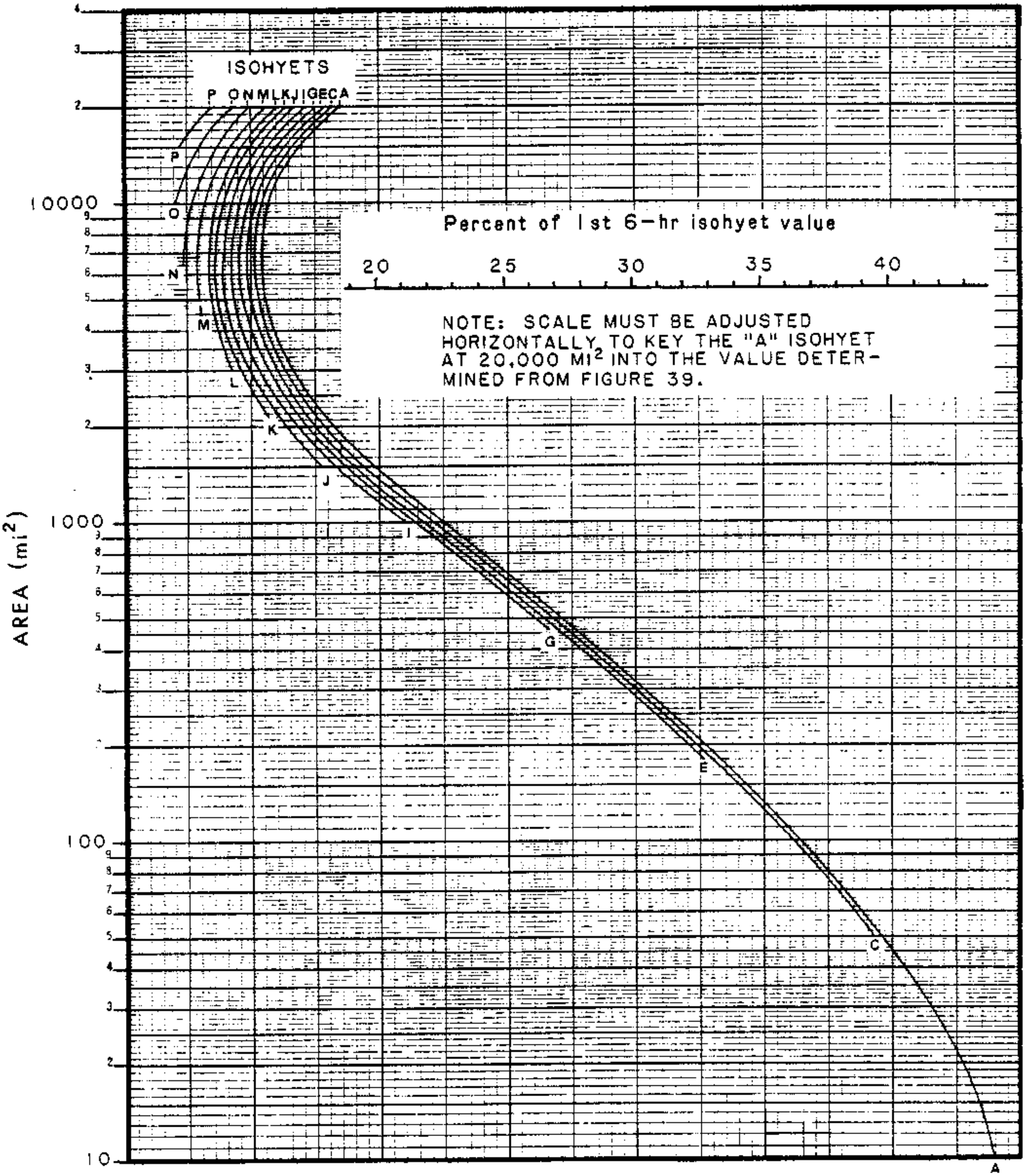

Figure 40.--Regionally-averaged nomogram for 1-hr isohyet values in percent of 1st 6-hr isohyet values.

may be read directly from the nomogram as percents of the corresponding 6-hr isohyet values.

Once all isohyet values have been read, the ratios are multiplied by the greatest 6-hr isohyet values to get the 1-hr isohyet values. Because of the areal limitations discussed in section 6.4, we suggest that isohyet values for any durations less than 1 hr also be limited to small pattern areas (< 200 mi^2). For such cases, short duration isohyet values can be interpolated from smooth curves connecting the 1-, 6-, 12-, 18- and 24-hr values to zero. Following this procedure for areas larger than 200 mi^2 will result in pattern-averaged depths that are less than that of PMP determined from figures 36-38.

6.5.3 Isohyet values for short duration residual isohyets

Attempts were made to obtain values for isohyets describing residual precipitation along similar lines as discussed above. However, the results were confusing and the procedure abandoned. It was decided that the alternative was to allow interpolation from smoothed depth-duration curves drawn through isohyet values for the 6-, 12-, 18- and 24-hr durations connected to zero. These curves are relatively more flat than those for isohyets in the PMP portion of the pattern, especially those enclosing the smaller areas. Flatter curves allow the least flexibility in fitting the curve for durations less than 6 hr, and therefore the error involved in this decision is minimized.

7. PROCEDURE AND EXAMPLE APPLICATION

Chapters 2 through 6 describe the development of guidance for distributing storm-area averaged PMP from HMR No. 51 over a specific drainage. Since much of this material and the considerations involved in its application are unique to this study and represent a relatively complex computational process, it is believed useful to summarize the results of the study in the form of a stepwise procedure. To further emphasize the meaning of each of the steps, two examples are fully detailed as additional insight into the methods recommended.

Because of the complexity involved in the use of these procedures and the acknowledged length of time required to complete one application, it is recommended that the procedure be automated by those users having access to such capability.

7.1 Stepwise Procedure

The following stepwise procedure is recommended for distributing storm-area averaged PMP over a drainage. In addition, some guidance considerations are provided to aid the user when a subjective decision is required.

A. 6-Hr Incremental PMP (refer to HMR No. 51)

Step

1. Obtain depth-area-duration (D.A.D) data from figures 18 through 47 in HMR No. 51 for the location of the drainage. Location is customarily judged at or near the center of the drainage. For particularly large drainages in which isohyetal pattern placements may be made at considerable

distance from the drainage center, the location of the pattern center should be used to obtain the appropriate D.A.D data.

2. Plot the data in step A1 on semi-logarithmic paper (area on the log scale) and join points of common duration with curves. When drawing a smooth set of curves, we recommend that the curves be adjusted to assure that they are either parallel or show slight convergence with increasing area size; i.e., the largest incremental differences occur at 10 mi^2, and the smallest incremental differences occur at 20,000 mi^2 in HMR No. 51.

3. From the curves in step A2, read off D.A.D values for a set of standard isohyet area sizes* both larger and smaller than the area size of the specific drainage. Where possible, it is recommended that at least 4 pattern area sizes larger and smaller be used to adequately enclose the area size corresponding to maximum precipitation volume (see step C11).

4. For each of the pattern area sizes selected in step A3, plot the depth-duration data (at least to 48 hr) on linear paper and fit a smooth curve to enable interpolation of values for the 18-hr duration.

5. Obtain incremental differences for each of the first three 6-hr periods (0 to 6, 6 to 12, and 12 to 18 hr) through successive subtraction for each area size considered in step A4. Because of possible inaccuracies in reading the map analyses, plotting, and drawing for the data in the preceding steps, the 6-hr incremental values should also be plotted (on semi-log paper) and smoothed to insure a consistent data set. Incremental data should decrease or remain constant with increases in both duration and pattern area size. In drawing these final smoothing curves choose a scale for the abscissa (incremental depths) that allows values from curves to be read off to the nearest hundredth.

B. Isohyetal Pattern

Step

1. A tracing of the drainage should be placed over the isohyetal pattern in figure 5, drawn at comparable map scales. Placement of the pattern (or adjustment of the drainage axis) is a subjective consideration. Placement is generally regarded as that which inputs the maximum

*The standard isohyet area sizes are those of: 10, 25, 50, 100, 175, 300, 450, 700, 1,000, 1,500, 2,150, 3,000, 4,500, 6,500, 10,000, 15,000, 25,000, 40,000, and 60,000 mi^2.

precipitation to the drainage. In most cases this consideration is met by drainage-centering the isohyetal pattern, that is, the isohyetal and drainage patterns have approximately the same center and axial orientation (see section 4.4.4 for exception). Judgment is guided by trying to place the greatest number of whole isohyets completely within the drainage, since the isohyets that enclose smaller area sizes contain proportionately higher rain amounts. This guidance is subject to consideration of the relative orientations preferred for PMP-type patterns discussed in the following steps.

2. Determine the orientation (to nearest whole degree) of the pattern when placed on the drainage, in terms of degrees from north. If this orientation does not fall between 135° and 315°, add 180° so that it does.

3. Determine the orientation preferred for PMP conditions from figure 8 at the location of the pattern center. If the difference between orientations from step B3 and B2 is less than 40 degrees, then for the isohyetal pattern as placed over the drainage there is no reduction factor to consider. If the orientation differences exceed 40 degrees, then a decision must be made whether the pattern is to be placed at some angle to the drainage at which no reduction to isohyet values is required, or aligned with the drainage and a reduction made to the isohyet values. A truly objective decision on the orientation of the pattern yielding maximum volume would require numerous applications. As guidance, the area size of the drainage, the shape of the drainage, and the differences in orientations (preferred PMP and pattern placed on the drainage) have the greatest bearing on the volume of precipitation determined. Only the experience gained from numerous trials will enable the user to reduce the effort involved in making these decisions. An illustration of the effects of alternative placements is demonstrated in the examples.

4. Skip this step if no adjustment for orientation is needed. Having settled on a placement of the isohyetal pattern, determine the appropriate adjustment factors due to orientation for the isohyets involved from the model shown in figure 10 (read to tenths of percent). Note that the amount of reduction is dependent upon area size (only pattern areas larger than 300 mi^2 need to be reduced) and the difference between orientations. Multiply the adjustment factor times the corresponding 6-hr incremental amounts from step A5 for each pattern area size to obtain incremental values reduced as a result of pattern orientation.

C. Maximum Precipitation Volume

Determine the maximum volume of precipitation for the three largest 6-hr incremental periods resulting from placement of the pattern over the drainage. To do this, it is necessary to obtain the value to be assigned to each isohyet in the pattern that occurs over the drainage during each period. Guidance for this determination is given in the following steps related to the format presented in figure 41. It is suggested that an ample number of copies of this figure be reproduced to serve in the computation procedure.

Step

Start by determining the maximum volume for the 1st 6-hr incremental period.

1. Fill in the name of the drainage, drainage area, date of computation, and increment (either 1st, 2nd or 3rd) in the appropriate boxes at top of form (fig. 41).

2. Put the area size (mi^2) from step A3 for which the first computation is made under the heading at the upper left of form.

3. Column I contains a list of isohyet labels. Use only as many isohyets as needed to cover the drainage.

4. For the area size in step C2, list in column II the corresponding percentages read from table 15 or the nomogram in figure 16 (first 6-hr period) for those isohyets needed to cover the drainage; use table 16 or figure 18 and table 17 or figure 19 for the 2nd and 3rd 6-hr periods, respectively, when determining step C10.

5. Under the heading amount (Amt.) in column III place the value from step B4 corresponding to area size and increment of computation. Multiply each of the percentages in column II by the Amt. at the head of column III to fill column III.

6. Column IV represents the average depth between adjacent isohyets. The average depth of the "A" isohyet is taken to be the value from column III. The average depth between all other isohyets which are totally enclosed by the drainage is the arithmetic average of paired values in column III. For incomplete isohyets covering the drainage, it is necessary to make a weighted estimate of the average depth if a portion of the drainage extends beyond a particular isohyet. The average depth for the extended portion of the drainage may be taken as 0.5 to 1.0 times the difference between the enclosing isohyets plus the lower isohyet. The weighting relation is given by:

$$F\ (X-Y) + Y$$

where X and Y are adjacent isohyet values, $X \geq Y$, and the weight factor, F, may be between 0.5 and 1.0. If only a small portion of the drainage extends beyond X, then the

Figure 41.—Example of computation sheet showing typical format.

Increment: ______

Drainage: ____________________ Area: ________ Date: ________

	I	II	III	IV	V	VI
Area size	Iso.	Nomo.	Amt.	Avg. depth	ΔA	ΔV
	A					
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					
	N					
	O					
	P					
					Sum =	

	I	II	III	IV	V	VI
Area size	Iso.	Nomo.	Amt.	Avg. depth	ΔA	ΔV
	A					
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					
	N					
	O					
	P					
					Sum =	

Area size		Amt.
	A	
	B	
	C	
	D	
	E	
	F	
	G	
	H	
	I	
	J	
	K	
	L	
	M	
	N	
	O	
	P	

Sum =

Area size		Amt.
	A	
	B	
	C	
	D	
	E	
	F	
	G	
	H	
	I	
	J	
	K	
	L	
	M	
	N	
	O	
	P	

Sum =

Area size		Amt.
	A	
	B	
	C	
	D	
	E	
	G	
	H	
	I	
	J	
	K	
	L	
	M	
	N	
	O	
	P	

Sum =

Area size		Amt.
	A	
	B	
	C	
	D	
	E	
	G	
	H	
	I	
	J	
	K	
	L	
	M	
	N	
	O	
	P	

Sum =

weight factor may be taken closer to 1.0, and if the drainage extends nearly to Y, then a weight factor close to 0.5 is appropriate.

7. Column V lists the incremental areas between adjacent isohyets. For the isohyets enclosed by the drainage, the incremental area can be obtained from table 8. For all other isohyets it will be necessary to planimeter the area of the drainage enclosed by each isohyet and make the appropriate successive subtractions. The sum of all the incremental areas in column V should equal the area of the drainage. If the computation in step 5 results in the zero isohyet's crossing the drainage, the appropriate total area is that contained within the zero isohyet, and not the total drainage area.

8. Column VI gives the incremental volume obtained by multiplying values in column IV times those in column V. The incremental volumes are summed to obtain the total volume of precipitation in the drainage for the specified pattern area size in the 6-hr period.

9. Steps C2 to C8 are repeated for all the other pattern area sizes selected in step A3.

10. The largest of the volumes obtained in steps C8 and C9 represents the preliminary maximum volume for the 1st 6-hr incremental period and specifies the pattern area to which such volume relates. The area of maximum volume can be used as guidance in choosing pattern areas to compute volumes for the 2nd and 3rd 6-hr incremental period. Presumably, this guidance narrows in on the range of pattern area sizes considered and possibly reduces in some degree the number of computations. Compute the 2nd and 3rd 6-hr incremental volumes by repeating steps C1 to C9, using the appropriate tables or nomograms.

11. Sum the volumes from steps C8 to C10 at corresponding area sizes and plot the results in terms of volume vs. area size (semi-log plot). Connect the points to determine the area size for the precipitation pattern that gives the maximum 18-hr volume in the drainage.

12. It is recommended, although not always necessary, that the user repeat steps C2 through C11 for one or two supplemental area sizes (area sizes other than those of the standard isohyetal pattern) on either side of the area size of maximum volume in step C11. This provides a check on the possibility that the maximum volume occurs between two of the standard isohyet area sizes. To make this check, an isohyet needs to be drawn for each supplemental area size in the standard isohyetal pattern and positioned on the drainage so that the corresponding incremental areas between isohyets can be determined (planimetered). In addition, supplemental cusp points need to be determined in figures

16, 18 and 19 for each of the area sizes considered. To find the appropriate cusp position, enter the ordinate at the supplemental area size, and move horizontally to intersect a line between the two most adjacent cusps. This intermediate point will be the percentage for the supplemental isohyet when reading the other isohyet percentages in step C4; otherwise follow the computational procedure outlined.

13. The largest 18-hr volume obtained from either step C11 or C12 then determines the final pattern area size of maximum volume for the pattern placement chosen in step B1.

D. Distribution of Storm-Area Averaged PMP over the Drainage

Step

1. For the pattern area size for PMP determined in step C13, use the data in step A3 to extend the appropriate depth-duration curve in step A4 to 72-hr, and read off values from the smoothed curve for each 6 hr (6 to 72 hr).

2. Obtain 6-hr incremental amounts for data in step D1 for the 4th through 12th 6-hr periods in accordance with step A5, and follow procedural steps B1 to B4 to adjust these incremental values for isohyetal orientation, if needed.

3. Steps D1 and D2 give incremental average depths for each of the 12 6-hr periods in the 72-hr storm. To obtain the values for the isohyets that cover the drainage, multiply the 1st 6-hr incremental depth by the 1st 6-hr percentages obtained from table 15 or the nomogram (fig. 16) for the area size determined in step C13. Then multiply the 2nd 6-hr incremental depth by the 2nd 6-hr percentages from table 16 or the nomogram (fig. 18) for the same area size, and similarly for the 3rd 6-hr increment (table 17 or fig. 19). Finally, multiply each remaining 6-hr incremental depth by the 4th through 12th percentages in table 18 or the nomogram (fig. 20). As a result of this step, a matrix of the following form can be completed (to the extent of whichever isohyets cover the drainage).

	6-hr periods											
Isohyet (in.)	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C					Isohyet Values (in.)							
etc.												

4. To obtain incremental average depths for the drainage, compute the incremental volumes for the area size of the PMP

pattern determined in step C10. Divide each incremental volume by the drainage area (that portion covered by precipitation).

5. Should it be of interest to determine the isohyetal values for durations less than 6 hr within the greatest 6-hr increment, the procedure discussed in section 6.3 gives the following steps.

   a. Interpolate the 1/6-hr ratio at the drainage location from figure 39.

   b. Adjust an overlay of the scale given in figure 40 along the abscissa of the figure such that the 20,000-mi^2 "A" isohyet equals the ratio read in step D5a.

   c. At the area size for the PMP pattern found in step C10, read from the nomogram (fig. 40) percentages of the 6-hr isohyet values. These isohyets cover only the PMP portion of the pattern.

   d. Multiply the ratio in step D5c by the corresponding 6-hr isohyet values in step D3 to obtain 1-hr isohyet values.

   e. Plot the values from step D5d along with the 6-, 12-, 18-, and 24-hr isohyet values for each isohyet from step D3. Draw a smooth curve of best fit through points for each isohyet to include the origin.

   f. Read off isohyet values for any other intermediate duration of interest. Note that the values interpolated from these smooth curves, 5-, 15-, and 30-min durations, will result in somewhat lower drainage-averaged PMP estimates than obtained from figures 36-38.

   g. To obtain isohyet values for any isohyet of residual precipitation in the PMP pattern, plot the 6-, 12-, 18- and 24-hr isohyet values from step D3 and fit a smooth curve through the points to include the origin. Read off isohyet values for any intermediate duration. (Note in step D5f is also valid for 1-hr values in this step.)

E. Temporal Distribution

In the matrix in step D3, storm-area averaged PMP has been distributed according to increasing 6-hr period. The discussion in chapter 2 provides guidance on distributing these incremental periods with time. A number of distributions are possible, with the choice being left to the user, depending on which is most appropriate for the drainage under study. Whatever distribution is selected must be applied to all isohyets. An example of one possible distribution is reordering the 6-hr incremental periods in step D3 as follows:

6-hr periods

1	2	3	4	5	6	7	8	9	10	11	12
11	10	8	5	1	2	3	4	6	7	9	12

F. Subdrainages

Should it be necessary to determine the areal distribution of PMP across subdrainages of a particular drainage, consider the following steps:

Step

1. With the pattern placed across the entire drainage as given in step B1, and incremental isohyet values as determined in step D3 and/or D5, planimeter the incremental areas contained between isohyets within each subdrainage.

2. Follow the computational procedure outlined in steps C5 to C8 to obtain the incremental subdrainage volumes for 6-hr periods 1 through 12.

3. The subdrainage volumes divided by the subdrainage areas yield the average depths across the subdrainage for each 6-hr increment.

   Note: If the subdrainage is crossed by the zero isohyet, the appropriate area for consideration is the subdrainage area inside the zero isohyet, not that of the total subdrainage.

4. If it is hydrologically critical to rearrange the temporal sequence of the incremental amounts determined in step F3 for a particular subdrainage, then it is necessary that the same arrangement be applied to all other subdrainages. This requirement is important and must be observed without exception. Demonstration of a subdrainage application is given in example 2a.

7.2 Example No. 1a

The first example demonstrates the computational procedure, and shows the affect on maximum volume determination that results from consideration of orientation of the isohyetal pattern.

The drainage used in this example is that of the Leon River in Texas above Belton Reservoir (approximately 3,660 mi^2) shown in figure 42, drawn to a scale of 1:1,000,000. Drainage center is about 31°45'N, 98°15'W.

The following steps correspond to those outlined in section 7.1 leading to determination of the area size of the isohyetal pattern that gives maximum volume, from which we then assign isohyet values.

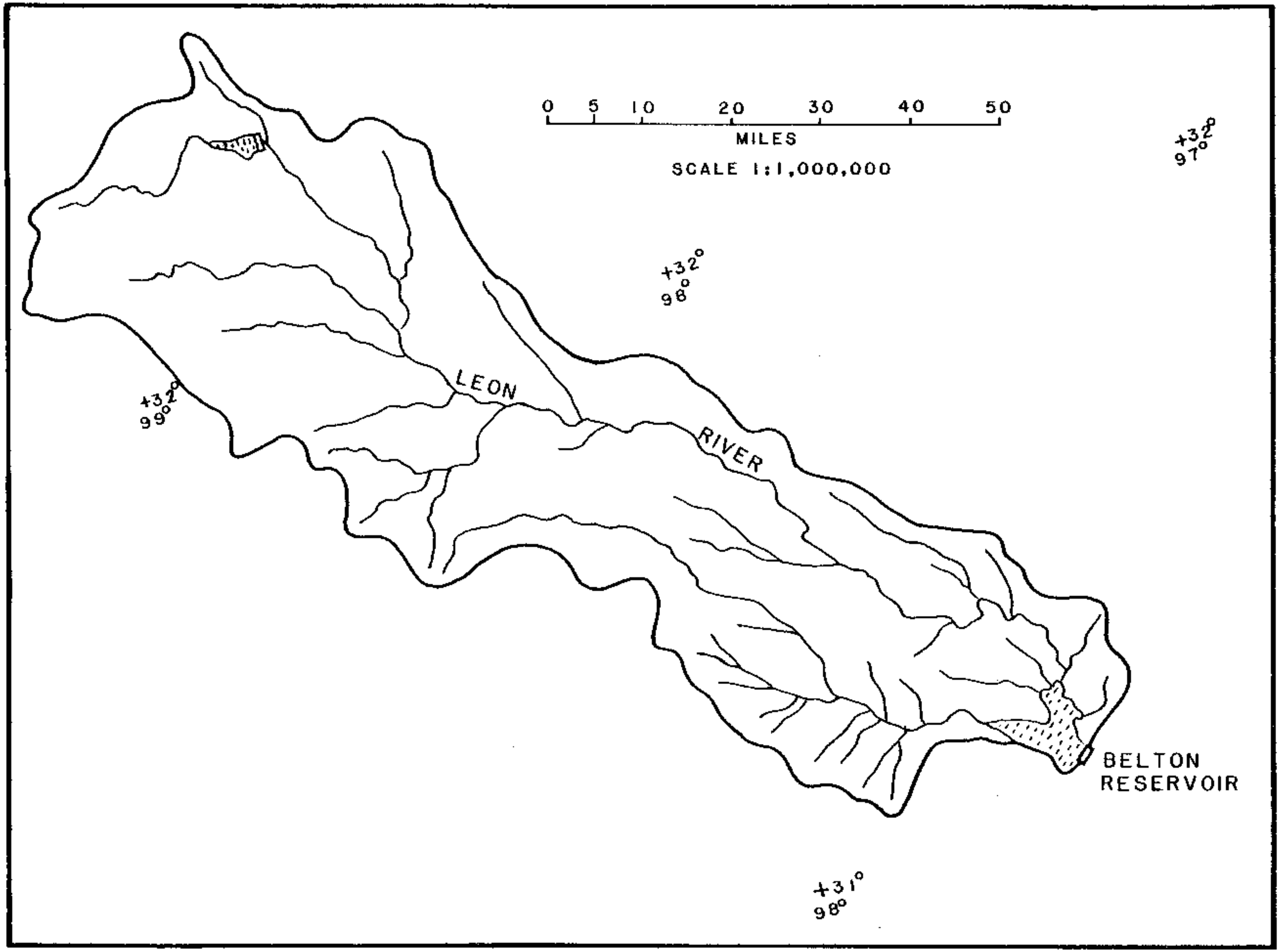

Figure 42.—Leon River, TX (3,660 mi^2) above Belton Reservoir showing drainage.

Step

A1. For the Leon River drainage above Belton Reservoir (31°45°N, 98°15'W) we obtain storm-area averaged PMP data from HMR No. 51, figures 18 through 47 as,

	Duration (hr)				
Area (mi^2)	6	12	24	48	72
10	29.8	36.2	41.8	46.7	49.8
200	22.3	27.4	33.0	37.5	41.4
1000	16.2	21.2	26.8	31.0	34.5
5000	9.3	13.1	18.1	22.6	25.9
10000	7.2	10.4	14.9	18.8	21.0
20000	5.2	8.2	11.7	15.4	18.4

A2. The depth-area-duration data in step A1 is plotted in figure 43, and smooth curves drawn. The decision on how to smooth these curves to the data points is left to the user, although it is cautioned they are to be parallel or converge slightly with increasing area size.

A3. From figure 43, we can read off values for the standard areas of isohyets both larger and smaller than the drainage area (3,660 mi^2).

	Duration (hr)				
Area (mi^2)	6	12	24	48	72
1000	16.1	20.7	26.1	30.5	34.1
1500	14.4	18.9	24.1	28.5	32.0
2150	12.9	17.2	22.3	26.7	30.2
3000	11.5	15.7	20.6	25.0	28.5
4500	9.8	13.9	18.6	22.8	26.4
6500	8.5	12.4	16.7	21.0	24.3
10000	7.1	10.6	14.8	18.8	22.0
15000	5.9	9.3	13.0	16.8	20.0

A4. The data in step A3 are plotted on linear paper and smooth depth-duration curves drawn as shown in figure 44. From these curves we interpolate 18-hr values:

Area (mi^2)	18-hr Duration
1000	23.7
1500	21.8
2150	20.0
3000	18.5
4500	16.5
6500	14.8
10000	13.0
15000	11.3

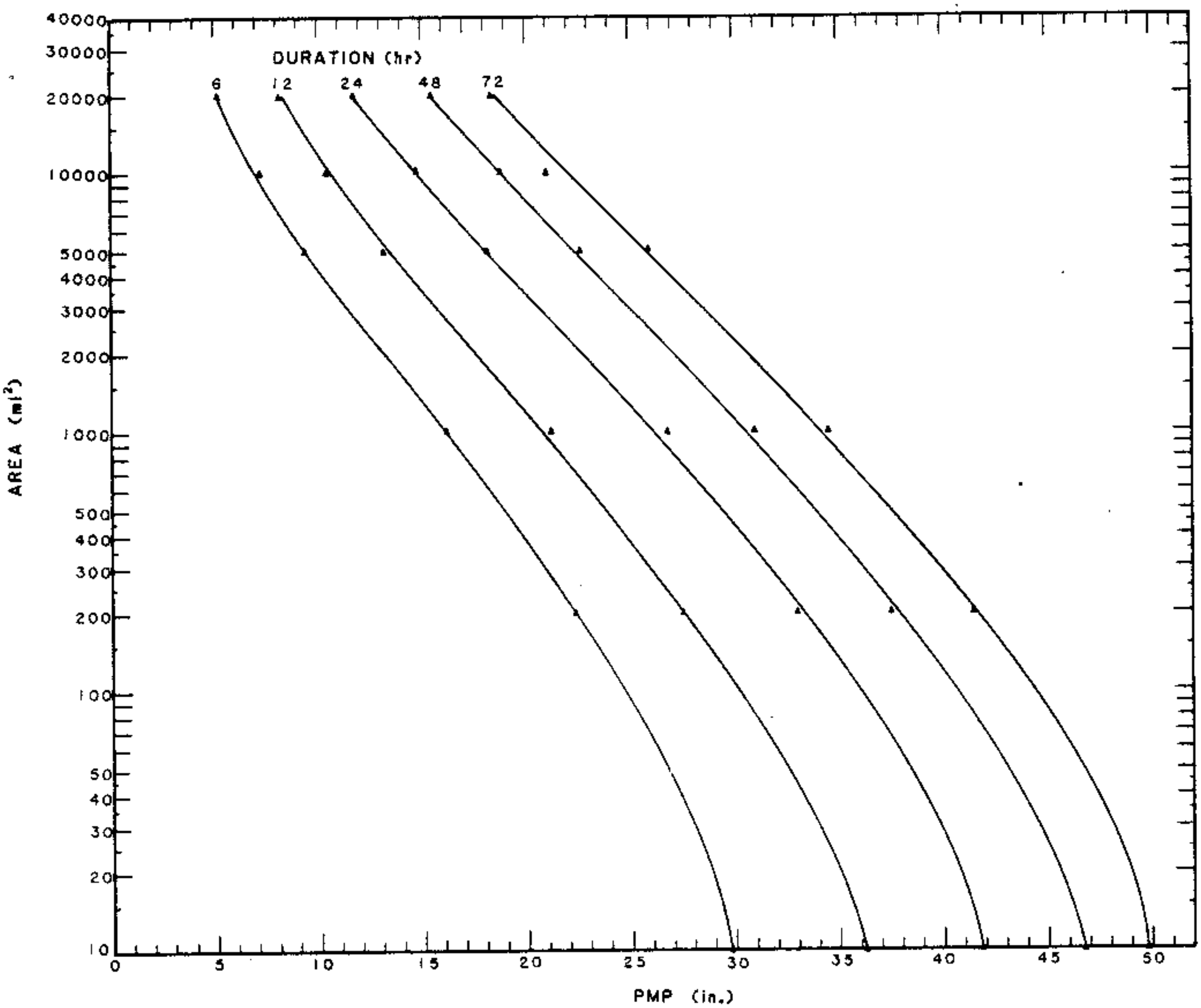

Figure 43.—Depth-area-duration curves for 31°45'N, 98°15'W applicable to the Leon River, TX drainage.

A5. Incremental differences for the 1st three 6-hr periods are obtained by successive subtraction of the values contained in steps A3 and A4.

	6-hr periods		
Area (mi^2)	1	2	3
1000	16.1	4.6	3.0
1500	14.4	4.5	2.9
2150	12.9	4.3	2.8
3000	11.5	4.2	2.8
4500	9.8	4.1	2.6
6500	8.5	3.9	2.4
10000	7.1	3.5	2.4
15000	5.9	3.4	2.0

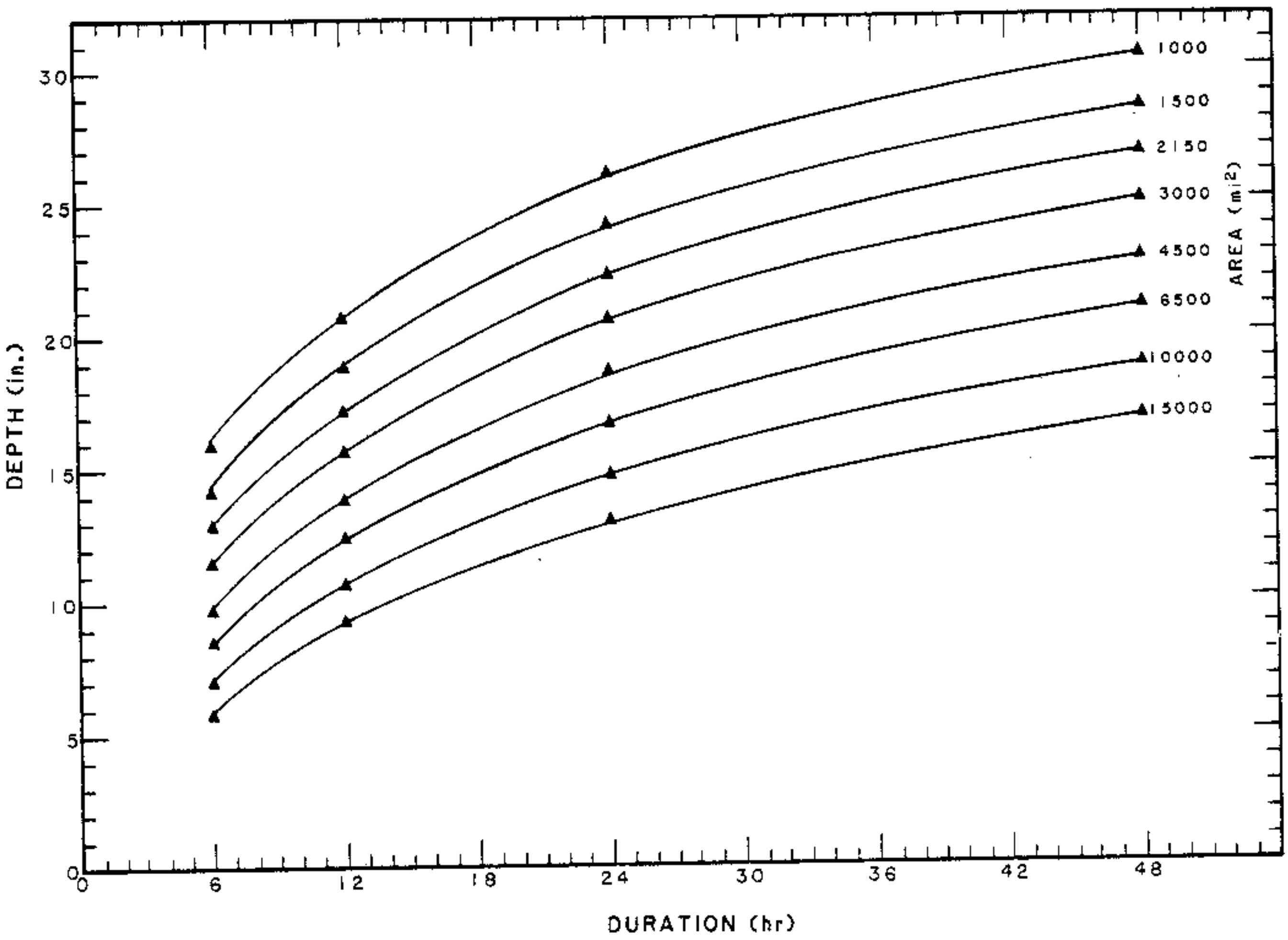

Figure 44.—Depth-duration curves for selected area sizes at 31°45'N, 98°15'W.

Plotting each set of 6-hr values against area and fitting the points by smooth lines as shown in figure 45 gives the following set of incremental data (read to hundredths).

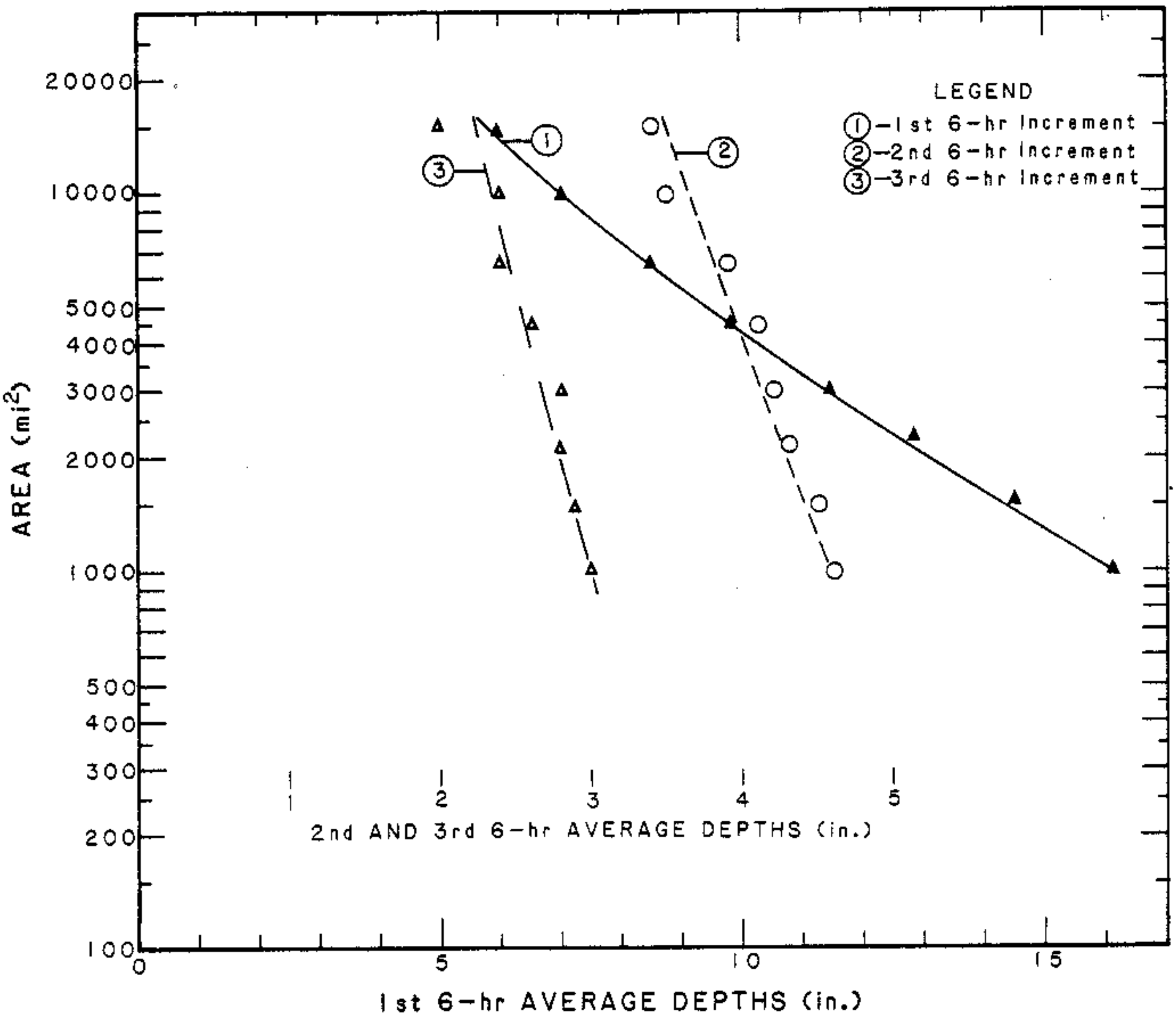

Figure 45.--Smoothing curves for 6-hr incremental values at selected area sizes for Leon River, TX drainage.

	6-hr periods		
Area (mi²)	1	2	3
1000	16.10	4.60	3.01
1500	14.35	4.42	2.89
2150	12.82	4.27	2.79
3000	11.40	4.14	2.70
4500	9.80	3.96	2.58
6500	8.50	3.82	2.48
10000	7.05	3.66	2.36
15000	5.80	3.50	2.25

Note that within each column as a result of this smoothing, the values consistently decrease with increasing area size.

B1. The isohyetal pattern is then drainage-centered over the Leon River drainage drawn to 1:1,000,000 scale as shown in figure 46. Our judgment of best fit enclosed the "H" isohyet within the narrow outline of the drainage. The "N" isohyet encloses almost all the drainage.

B2. The orientation of the pattern, when fit as in figure 46 is roughly 134°/314°. The 134° misses by 1° our preferred range (135° to 315°) and we accordingly added 180° to get an orientation of 314°.

B3. For the location of the drainage center at 31°45'N and 98°15'W, figure 8 gives the PMP orientation of 208°. The angular difference is 314°-208°, or 106°. Since this difference, or its supplement, 74°, exceeds our range of ±40° for which no reduction to PMP is applied, we must adjust the storm-area averaged PMP for orientation of the pattern when aligned with the drainage.

B4. Figure 10 gives the following reductions for the various isohyet areas considered in step A3 and the orientation difference from PMP given in step B3.

Pattern area (mi^2)	Adjustment factor (%)
1000	96.1
1500	93.3
2150	89.7
3000	85.0
4500	85.0
6500	85.0
10000	85.0
15000	85.0

Multiply each of the final smoothed 6-hr incremental values in step A5 by the adjustment factors of step B4 to get the adjusted incremental values,

	6-hr periods		
Pattern area (mi^2)	1	2	3
1000	15.47	4.42	2.89
1500	13.39	4.12	2.70
2150	11.50	3.83	2.50
3000	9.69	3.52	2.30
4500	8.33	3.37	2.19
6500	7.22	3.25	2.11
10000	5.99	3.11	2.01
15000	4.93	2.98	1.91

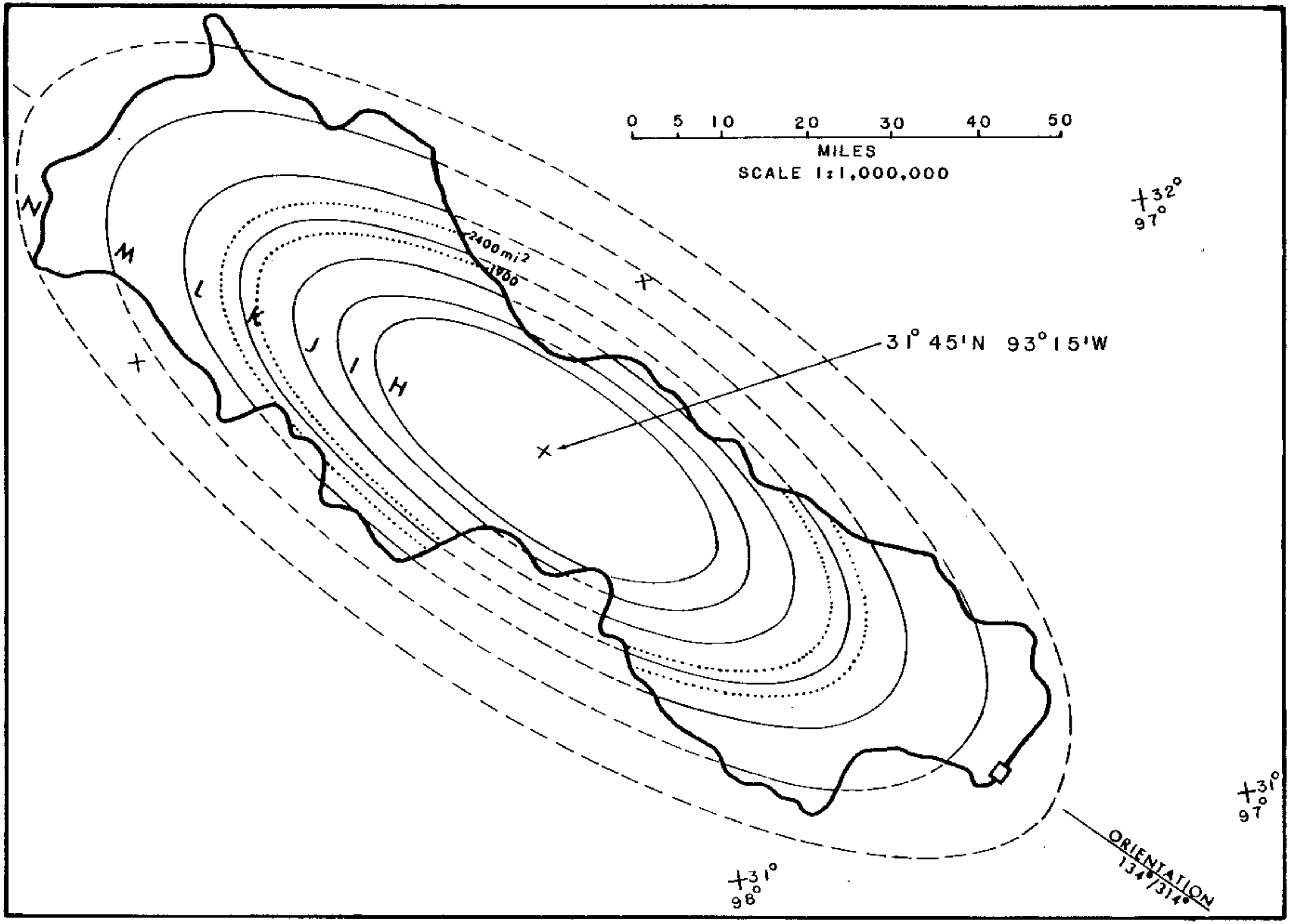

Figure 46.--Isohyetal pattern placed on the Leon River, TX drainage to give maximum precipitation volume.

C. Determine the maximum volume of precipitation for the PMP patterns corresponding to the 8 area sizes used in the previous steps. To do this, we recommend filling in the computation sheets as shown in table 22. Some preliminary considerations have been made regarding the fit of the isohyetal pattern over the drainage. First, the small (~10-mi^2) area of the drainage outside the N isohyet has been disregarded as insignificant to overall volume. Second, weight factors of 0.6 and 0.75 have been assigned (arbitrary judgment) to the average depth calculation for the L to M and M to N isohyetal areas, respectively (see step C6).

Following the procedure outlined in section C, we find the greatest volume for the 1st 6-hr increment occurs at 1,500 mi^2. We should then check the volumes obtained for the 2nd and 3rd 6-hr increments before accepting 1,500 mi^2 as our answer. For these additional increments it is not necessary to calculate volumes for all the areas considered in the 1st 6-hr increment, only those in the vicinity of the presumed area of maximum volume (1,500 mi^2). Thus, we have limited our calculations to areas between 1,000 and 3,000 mi^2 (table 22). Addition of the incremental volumes at corresponding area sizes shows, however, that the maximum volume has shifted from 1,500 mi^2 to 2,150 mi^2 for these accumulated volumes. (The sum of the 1st to 3rd volumes is shown by the solid line in fig. 47.)

It is of interest to narrow in on this maximum as to area size, and we chose to evaluate two supplementary PMP pattern areas at 1,900 and 2,400 mi^2. Isohyets for these area sizes have been added to figure 46 as dotted lines. The results from table 23 (dashed lines in figure 47) show a maximum volume occurs at an area size slightly less than that for the 2,150-mi^2 area pattern in the Leon River drainage.

Because of the shift of area size between the 1st and the sum of the 1st three increments, it has been recommended that the three greatest increments be determined in the computation procedure. This significantly increases the number of computations required.

Step

D1. Having concluded that the maximum volume occurs for a PMP pattern near 2,150 mi^2 when placed over the Leon River, we can now determine the values for each isohyet for all twelve 6-hr increments. Return to the smooth depth-duration curve for 2,150 mi^2 in step A4, and extend this curve to 72 hr before reading off the 6-hr values.

	Duration (hr)											
	6	12	18	24	30	36	42	48	54	60	66	72
Increm. PMP (in.)	12.9	17.2	20.0	22.3	23.8	25.0	26.0	26.8	27.7	28.5	29.2	29.9

Table 22.—Completed computation sheets for 1st, 2nd and 3rd 6-hr increments for Leon River, TX drainage

Increment: 1

Drainage: Leon River, TX   Area: 3,660 mi²   Date: ______

Area size	I Iso.	II Nomo.	III Amt. 15.47	IV Avg. depth	V ΔA	VI ΔV
	A	149	23.05	23.05	10	230.5
	B	140	21.66	22.36	15	335.4
1000/1	C	131	20.27	20.97	25	524.2
	D	122	18.87	19.57	50	978.5
	E	113	17.48	18.18	75	1363.5
	F	104	16.09	16.79	125	2098.8
	G	97	15.01	15.55	150	2332.5
	H	89	13.77	14.39	250	3597.5
	I	82	12.69	13.23	271	3585.3
	J	60	9.28	10.99	393	4319.1
	K	44	6.81	7.69	488	3752.7
	L	32	4.95	5.88	582	3422.2
(.60 X)*	M	21	3.25	4.27	737	3146.9
(.75 X)	N	12	1.85	3.09	489	1511.0
					Sum =	31198.1

Area size	I Iso.	II Nomo.	III Amt. 9.69	IV Avg. depth	V ΔA	VI ΔV
	A	191	18.51	18.51	10	185.1
	B	179	17.93	17.93	15	258.9
3000/1	C	166	16.09	16.72	25	418.0
	D	154	14.92	15.51	50	775.5
	E	142	13.76	14.34	75	1075.5
	F	132	12.79	13.28	125	1660.0
	G	122	11.82	12.31	150	1846.5
	H	112	10.85	11.34	250	2835.0
	I	102	9.88	10.37	271	2810.3
	J	92	8.91	9.39	393	3690.3
	K	83	8.04	8.48	488	4138.2
	L	74	7.17	7.61	582	4429.0
(.60 X)	M	44	4.26	6.01	737	4428.4
(.75 X)	N	25	2.42	3.80	489	1858.2
					Sum =	30418.9

Area size			Amt. 13.39			
	A	162	21.69	21.69	10	216.9
	B	152	20.35	21.02	15	315.8
1500/1	C	142	19.01	19.68	25	492.0
	D	132	17.67	18.34	50	917.0
	E	122	16.33	17.00	75	1275.0
	F	112	14.99	15.66	125	1957.5
	G	105	14.06	14.52	150	2178.0
	H	96	12.85	13.46	250	3365.0
	I	88	11.78	12.32	271	3338.7
	J	80	10.71	11.24	393	4417.3
	K	56	7.50	9.10	488	4440.8
	L	41	5.49	6.50	582	3783.0
(.60 X)	M	26	3.48	4.69	737	3456.5
(.75 X)	N	16	2.14	3.14	489	1535.5
					Sum =	31689.0

Area size			Amt. 8.33			
	A	212	17.66	17.66	10	176.6
	B	198	16.49	17.08	15	256.1
4500/1	C	184	15.33	15.91	25	397.8
	D	170	14.16	14.75	50	737.5
	E	157	13.08	13.62	75	1021.5
	F	146	12.16	12.62	125	1577.5
	G	135	11.25	11.71	150	1756.5
	H	124	10.33	10.79	250	2697.5
	I	113	9.41	9.87	271	2674.8
	J	103	8.58	9.00	393	3537.0
	K	93	7.75	8.16	488	3982.1
	L	83	6.91	7.33	582	4266.1
(.60 X)	M	71	5.91	6.51	737	4797.9
(.75 X)	N	37	3.08	5.20	489	2542.8
					Sum =	30421.7

Area size			Amt. 11.50			
	A	176	20.24	20.24	10	202.4
	B	165	18.98	19.61	15	294.2
2150/1	C	154	17.71	18.35	25	458.6
	D	142	16.33	17.02	50	851.0
	E	131	15.07	15.70	75	1177.5
	F	122	14.03	14.55	125	1818.8
	G	113	12.99	13.51	150	2026.5
	H	103	11.58	12.42	250	3105.0
	I	95	10.93	11.39	271	3086.7
	J	86	9.89	10.41	393	4091.1
	K	77	8.86	9.38	488	4577.4
	L	52	5.98	7.42	582	4318.4
(.60 X)	M	33	3.80	5.11	737	3766.1
(.75 X)	N	20	2.30	3.42	489	1672.4
					Sum =	31446.3

Area size			Amt. 7.22			
	A	233	16.82	16.82	10	168.2
	B	218	15.74	16.28	15	244.2
6500/1	C	203	14.66	15.20	25	380.0
	D	187	13.50	14.08	50	704.0
	E	174	12.56	13.03	75	977.3
	F	160	11.55	12.06	125	1507.5
	G	148	10.69	11.12	150	1668.0
	H	137	9.89	10.29	250	2572.5
	I	125	9.03	9.46	271	2563.7
	J	113	8.16	8.59	393	3375.9
	K	103	7.44	7.80	488	3806.4
	L	93	6.71	7.08	582	4120.6
(.60 X)	M	81	5.85	6.37	737	4694.7
(.75 X)	N	70	5.05	5.65	489	2762.8
					Sum =	29545.7

* Weighting factor F (see text Section 7.1 Step C6)

Table 22.—Completed computation sheets for 1st, 2nd and 3rd 6-hr increments for Leon River, TX drainage - Continued

Increment: 1,2

Drainage: Leon River, TX   Area: 3,660 mi^2 Date:

Area size	I Iso.	II Nomo.	III Amt. 5.99	IV Avg. depth	V ΔA	VI ΔV
	A	262	15.69	15.69	10	156.9
	B	243	14.56	15.12	15	226.8
10000/1	C	227	13.60	14.08	25	352.0
	D	209	12.52	13.06	50	653.0
	E	194	11.62	12.07	75	905.2
	F	178	10.66	11.14	125	1392.5
	G	166	9.94	10.30	150	1545.0
	H	152	9.10	9.52	250	2380.0
	I	140	8.39	8.74	271	2368.5
	J	128	7.67	8.03	393	3155.8
	K	117	7.01	7.34	488	3581.9
	L	107	6.41	6.71	582	3905.2
(.60 X)	M	93	5.57	6.07	737	4473.6
(.75 X)	N	82	4.91	5.40	489	2640.6
						Sum = 27737.0

Area size	I Iso.	II Nomo.	III Amt. 4.93	IV Avg. depth	V ΔA	VI ΔV
	A	290	14.30	14.30	10	143.0
	B	271	13.36	13.83	15	207.4
15000/1	C	253	12.47	12.92	25	323.0
	D	232	11.44	11.96	50	598.0
	E	214	10.55	11.00	75	825.0
	F	196	9.66	10.10	125	1262.5
	G	183	9.02	9.34	150	1411.0
	H	168	8.28	8.65	250	2162.5
	I	156	7.69	7.98	271	2162.6
	J	143	7.05	7.37	393	2896.4
	K	131	6.46	6.76	488	3298.9
	L	120	5.92	6.19	582	3602.6
(.60 X)	M	106	5.22	5.64	737	4156.7
(.75 X)	N	94	4.63	5.07	489	2479.2
						Sum = 25518.8

Area size			Amt. 4.42			
	A	116	5.13	5.13	10	51.3
	B	112	4.95	5.04	15	75.6
1000/2	C	108.5	4.80	4.88	25	121.9
	D	105	4.64	4.72	50	236.0
	E	103	4.55	4.60	75	345.0
	F	101	4.46	4.51	125	563.8
	G	99	4.38	4.42	150	663.0
	H	97	4.29	4.34	250	1085.0
	I	95	4.20	4.25	271	1151.8
	J	76	3.36	3.78	393	1485.5
	K	63	2.78	3.07	488	1498.2
	L	51	2.25	2.52	582	1466.6
(.60 X)	M	38	1.68	2.02	737	1488.7
(.75 X)	N	24	1.06	1.52	489	743.3
						Sum = 10975.7

Area size			Amt. 4.12			
	A	117	4.82	4.82	10	48.2
	B	113	4.66	4.74	15	71.1
1500/2	C	110	4.53	4.60	25	114.9
	D	107	4.41	4.47	50	223.5
	E	105	4.33	4.37	75	327.8
	F	103	4.24	4.29	125	535.6
	G	100.5	4.14	4.19	150	628.5
	H	99	4.08	4.11	250	1027.5
	I	97	4.00	4.04	271	1094.8
	J	95.5	3.93	3.97	393	1560.2
	K	75.5	3.11	3.52	488	1717.8
	L	605	2.49	2.80	582	1629.6
(.60 X)	M	45	1.85	2.23	737	1643.5
(.75 X)	N	31	1.28	1.71	489	836.2
						Sum = 11459.2

Area size			Amt. 3.83			
	A	118.5	4.54	4.54	10	45.4
	B	114.5	4.39	4.47	15	67.0
2150/2	C	110.5	4.25	4.32	25	108.0
	D	108.5	4.16	4.21	50	210.5
	E	106.5	4.08	4.12	75	309.0
	F	104.5	4.00	4.04	125	505.0
	G	102	3.91	3.96	150	594.0
	H	100	3.83	3.96	250	967.5
	I	99	3.79	3.81	271	1032.5
	J	97	3.72	3.76	393	1477.7
	K	96	3.68	3.70	488	1805.6
	L	73	2.80	3.24	582	1885.7
(.60 X)	M	54	2.07	2.62	737	1930.9
(.75 X)	N	37.5	1.44	1.91	489	934.0
						Sum = 11872.8

Area size			Amt. 3.52			
	A	119.5	4.21	4.21	10	42.1
	B	116	4.08	4.15	15	62.2
3000/2	C	112.5	3.96	4.02	25	100.5
	D	110	3.87	3.92	50	196.0
	E	108	3.80	3.84	75	288.0
	F	106	3.77	3.77	125	471.2
	G	104	3.66	3.70	150	555.0
	H	102	3.59	3.63	250	907.5
	I	100.5	3.54	3.56	271	964.8
	J	99	3.48	3.51	393	1379.4
	K	97	3.41	3.45	488	1683.6
	L	96	3.38	3.40	582	1978.8
(.60 X)	M	67	2.36	2.97	737	2188.9
(.75 X)	N	45	1.58	2.17	489	1061.1
						Sum = 11879.1

Table 22.—Completed computation sheets for 1st, 2nd and 3rd 6-hr increments for Leon River, TX drainage – Continued

Increment: 3

Drainage: Leon River, TX Area: 3,660 mi^2 Date:

Area size	I Iso.	II Nomo.	III Amt. 2.89	IV Avg. depth	V ΔA	VI ΔV
	A	104.6	3.02	3.02	10	30.2
	B	103.3	2.98	3.00	15	45.0
1000/3	C	102.3	2.96	2.97	25	74.2
	D	101.3	2.93	2.945	50	147.2
	E	100.6	2.91	2.92	75	219.0
	F	100.3	2.90	2.905	125	393.1
	G	99.9	2.89	2.895	150	434.2
	H	99.6	2.88	2.885	250	721.2
	I	99.3	2.87	2.875	271	779.1
	J	82.5	2.38	2.70	393	1061.1
	K	67	1.94	2.16	488	1054.1
	L	54	1.56	1.75	582	1018.5
(.60 X)	M	43	1.24	1.43	737	1053.9
(.75 X)	N	31	.90	1.16	489	567.2
					Sum =	7598.0

Area size	I Iso.	II Nomo.	III Amt. 2.70	IV Avg. depth	V ΔA	VI ΔV
	A	105	2.84	2.84	10	28.4
	B	103.8	2.80	2.82	15	42.3
1500/3	C	102.7	2.77	2.785	25	69.6
	D	101.7	2.74	2.755	50	137.8
	E	101	2.73	2.735	75	205.1
	F	100.7	2.72	2.725	125	340.6
	G	100.3	2.71	2.715	150	407.2
	H	100	2.70	2.705	250	676.2
	I	99.7	2.69	2.695	271	730.3
	J	99.4	2.68	2.685	393	1055.2
	K	81	2.19	2.44	488	1190.7
	L	65.5	1.77	1.98	582	1152.4
(.60 X)	M	51.5	1.39	1.62	737	1193.9
(.75 X)	N	38	1.03	1.30	489	635.7
					Sum =	7865.4

Area size			Amt. 2.50			
	A	105.3	2.63	2.63	10	26.3
	B	104.2	2.60	2.615	15	39.2
2150/3	C	103.2	2.58	2.59	25	64.8
	D	102	2.55	2.565	50	128.2
	E	101.3	2.53	2.54	75	190.5
	F	101	2.52	2.525	125	315.6
	G	100.6	2.52	2.52	150	378.0
	H	100.3	2.51	2.515	250	628.8
	I	100	2.50	2.505	271	678.8
	J	99.7	2.49	2.495	393	980.5
	K	99.5	2.49	2.49	488	1215.1
	L	80.5	2.01	2.25	582	1309.5
(.60 X)	M	61	1.52	1.81	737	1334.0
(.75 X)	N	46.5	1.16	1.43	489	699.3
					Sum =	7988.6

Area size			Amt. 2.30			
	A	105.7	2.43	2.43	10	24.3
	B	104.6	2.41	2.42	15	36.3
3000/3	C	103.5	2.38	2.40	25	60.0
	D	102.5	2.36	2.37	50	118.5
	E	101.7	2.34	2.35	75	176.3
	F	101.3	2.33	2.345	125	293.1
	G	100.9	2.32	2.335	150	350.2
	H	100.5	2.31	2.315	250	578.8
	I	100.2	2.30	2.305	271	624.6
	J	99.9	2.30	2.30	393	903.9
	K	99.6	2.29	2.295	488	1120.0
	L	99.3	2.28	2.285	582	1329.9
(.60 X)	M	76	1.75	2.07	737	1525.6
(.75 X)	N	57	1.31	1.64	489	802.0
					Sum =	7943.5

Table 23.—Completed computation sheet for the 1st to 3rd 6-hr increments for supplemental isohyets on the Leon River, TX drainage

Increment: 1 to 3

Drainage: Leon River, TX Area: 3,660 mi^2 Date:

	I	II	III	IV	V	VI		I	II	III	IV	V	VI
Area size	Iso.	Nomo.	Amt. 12.12	Avg. depth	ΔA	ΔV	Area size	Iso.	Nomo.	Amt. 10.86	Avg. depth	ΔA	ΔV
	A	171	20.72	20.72	10	207.2		A	181	19.66	19.66	10	196.6
	B	160	19.39	20.06	15	300.9		B	169	18.35	19.00	15	285.0
1900/1	C	149	18.06	18.72	25	468.0	2400/1	C	158	17.16	17.76	25	444.0
	D	138	16.73	17.40	50	870.0		D	146	15.86	16.51	50	825.5
	E	128	14.51	16.12	75	1209.0		E	134	14.55	15.20	75	1140.0
	F	118	14.30	14.90	125	1862.5		F	125	13.58	14.06	125	1757.5
	G	110	13.33	13.82	150	2073.0		G	116	12.60	13.09	150	1963.5
	H	100	12.12	12.72	250	3180.0		H	106	11.51	12.06	250	3015.0
	I	93	11.27	11.70	271	3170.7		I	97	10.53	11.02	271	2986.4
	J	84	10.18	10.72	393	4213.0		J	88	9.56	10.04	393	3945.7
	-	78	9.45	9.82	345	3387.9		K	79	8.98	9.07	488	4426.2
	K	68	8.24	8.84	143	1264.1		-	76	8.25	8.42	211	1776.6
	L	48	5.82	7.03	582	4091.5		L	58	6.30	7.28	371	2700.9
(.60 X)	M	30	3.64	4.95	737	3548.2	(.60 X)	M	36	3.91	5.34	737	3935.6
(.75 X)	N	18	2.18	3.28	489	1603.9	(.75 X)	N	21	2.28	3.50	489	1711.5
					Sum =	31449.9						Sum =	31110.0
Area size			Amt. 3.93				Area size			Amt. 3.73			
	A	118	4.64	4.64	10	46.4		A	119	4.44	4.44	10	44.4
	B	116	4.56	4.60	15	69.0		B	115	4.29	4.36	15	65.4
1900/2	C	111	4.36	4.46	25	111.5	2400/2	C	112	4.18	4.24	25	106.0
	D	108	4.24	4.30	50	215.0		D	109	4.06	4.12	50	206.0
	E	106	4.16	4.20	75	315.0		E	107	3.99	4.025	75	301.9
	F	104	4.09	4.125	125	515.6		F	105	3.92	3.955	125	494.4
	G	102	4.01	4.05	150	607.5		G	103	3.84	3.88	150	582.0
	H	100	3.93	4.97	250	1242.5		H	101	3.77	3.805	250	951.2
	I	98	3.85	3.89	271	1054.2		I	99	3.69	3.73	271	1010.8
	J	96.5	3.79	3.82	393	1501.3		J	97.5	3.64	3.665	393	1440.3
	-	95.5	3.75	3.77	345	1300.6		K	96.5	3.60	3.62	488	1766.6
	K	86	3.38	3.57	143	510.5		-	96	3.58	3.59	211	757.5
	L	68	2.67	3.03	582	1763.5		L	78	2.91	3.25	371	1205.8
(.60 X)	M	50.5	1.98	2.39	737	1761.4	(.60 X)	M	57.5	2.14	2.60	737	1916.2
(.75 X)	N	37	1.48	1.86	489	909.5	(.75 X)	N	40	1.49	1.98	489	968.2
					Sum =	11923.5						Sum =	11816.7
Area size			Amt. 2.56				Area size			Amt. 2.43			
	A	105.2	2.69	2.69	10	26.9		A	105.4	2.56	2.56	10	25.6
	B	104.1	2.66	2.675	15	40.1		B	104.3	2.53	2.545	15	38.2
1900/3	C	103	2.64	2.65	25	66.2	2400/3	C	103.3	2.51	2.52	25	63.0
	D	102	2.61	2.625	50	131.2		D	102.3	2.48	2.495	50	124.8
	E	101.2	2.59	2.06	75	195.0		E	101.5	2.47	2.475	75	185.6
	F	100.8	2.58	2.585	125	323.1		F	101.0	2.45	2.46	125	307.5
	G	100.5	2.57	2.575	150	386.2		G	100.7	2.45	2.45	150	367.5
	H	100.2	2.56	2.565	250	641.2		H	100.3	2.44	2.445	250	611.2
	I	99.8	2.55	2.555	271	692.4		I	100.0	2.43	2.435	271	659.9
	J	99.6	2.55	2.55	393	1000.2		J	99.8	2.42	2.425	393	953.0
	-	99.4	2.54	2.545	345	878.0		K	99.4	2.42	2.42	488	1181.0
	K	92	2.36	2.45	143	350.4		-	99.3	2.41	2.415	211	509.6
	L	75	1.92	2.14	582	1245.5		L	86	2.09	2.25	371	834.8
(.60 X)	M	58	1.48	1.74	737	1285.3	(.60 X)	M	66	1.60	1.89	737	1392.9
(.75 X)	N	43	1.10	1.39	489	679.7	(.75 X)	N	49.5	1.20	1.50	489	733.5
					Sum =	7940.5						Sum =	7988.1

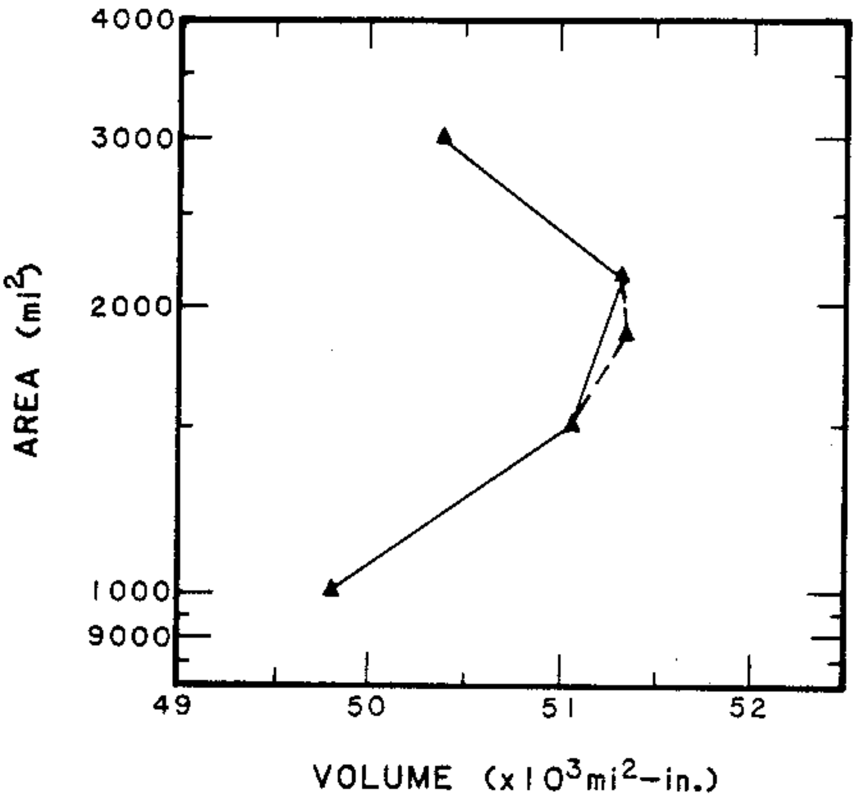

Figure 47.—Volume vs. area curve for 1st three 6-hr increments for Leon River, TX drainage.

D2. Successively subtract the 6-hr values in step D1.

6-hr periods

	1	2	3	4	5	6	7	8	9	10	11	12
Increm. PMP (in.)	12.9	4.3	2.8	2.3	1.5	1.2	1.0	0.8	0.9	0.8	0.7	0.7

We read slightly different values (read to hundreths) in smoothed data from figure 45 for the 1st three 6-hr increments, which we substitute here, for consistency.

Note that to assure a series of decreasing values it was necessary to reverse the values for the 8th and 9th increment. This does not cause any problem for our computations.

6-hr periods

	1	2	3	4	5	6	7	8	9	10	11	12
Increm. PMP (in.)	12.82	4.27	2.79	2.30	1.50	1.20	1.00	0.90	0.80	0.80	0.70	0.70

Multiply each of these 6-hr incremental PMP by 89.7% to reduce them for orientation.

	6-hr periods											
	1	2	3	4	5	6	7	8	9	10	11	12
Adj. PMP (in.)	11.50	3.83	2.50	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63

D3. Isohyet values are then obtained by multiplying the 1st 6-hr value in step D2 by the percentages for 2,150 mi^2 from table 15 or the 1st 6-hr nomogram (fig. 16), the 2nd 6-hr value by the percentages in table 16 or figure 18, the 3rd 6-hr value by the percentages in table 17 or figure 19, and the fourth through 12th 6-hr values by the percentages in table 18 or figure 20 as shown in table 24. In section 3.5.3, we have explained that the fourth through 12th 6-hr increments are assumed uniform. Thus, a constant value is used through the extent of the area size of PMP, 2,150 mi^2 in this example.

Table 24.--Isohyet values (in.), Leon River, TX, for example 1a

	6-hr periods											
Isohyet	1	2	3	4	5	6	7	8	9	10	11	12
A	20.24	4.54	2.63	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
B	18.98	4.39	2.61	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
C	17.17	4.25	2.58	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
D	16.33	4.16	2.56	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
E	15.07	4.08	2.53	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
F	14.03	4.00	2.53	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
G	12.99	3.91	2.52	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
H	11.85	3.83	2.51	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
I	10.93	3.77	2.50	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
J	9.89	3.72	2.49	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
K	8.86	3.68	2.48	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63
L	5.98	2.80	2.03	1.66	1.08	0.87	0.72	0.65	0.58	0.58	0.51	0.51
M	3.80	2.07	1.55	1.26	0.82	0.66	0.55	0.49	0.44	0.44	0.38	0.38
N	2.30	1.44	1.16	0.96	0.62	0.50	0.42	0.38	0.33	0.33	0.29	0.29

Note: The results shown in this matrix emphasize the fact that for the fourth through 12th 6-hr period the distribution of PMP is uniform across the PMP portion of the pattern (A through K) for each increment. However, isohyets L to N represent residual precipitation for the 2,150-mi^2 pattern and these isohyets are assigned decreasing values.

D4. The values in table 24 represent the incremental isohyetal values for the Leon River drainage with the 2,150-mi^2 PMP pattern placed as shown in figure 46. To obtain incremental average depths (PMP) for this drainage it is necessary to compute the incremental volumes as determined from the tabulated isohyetal values according to the procedures described for figure 41, and then divide each incremental volume by the drainage area. This results in the following incremental average depths. (See computations in table 25.)